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Comparative Osteology of Serranid Fishes of the Genus *Roccus* (Mitchill)[1]

WILLIAM S. WOOLCOTT

INTRODUCTION

THE serranid genus *Roccus* occurs between the parallels 50°N and 25°N and is represented by six species; *saxatilis, chrysops, americanus* and *interruptus* in North America, *labrax* and *punctatus* in Europe. The six species formerly were assigned to as many as five genera by authors. Jordan and Gilbert (1883:528–531), first to revise the genus, relegated the four American species to the genus *Roccus* (with *Morone* as a subgenus) and tentatively included the two European species. External characteristics were used as criteria. Later Berg (1949: 1012–1013) assigned them to a single genus, *Morone*, with three subgenera, and gave as diagnostic generic characters: (1) separate dorsal fins, (2) teeth present on the base of the tongue, and (3) absence of a supramaxillary bone. His classification of subgenera was also based primarily on external characters. The present osteological study was undertaken to check the validity of a monogeneric classification. Five species, *saxatilis, chrysops, americanus, interruptus* and *labrax*, were compared. The findings indicate that biologically the species are of a single genus. Subgenera may be defined using combinations of skeletal characters.

Starks (1901: fig. 45, pls. 63–65) used the skeleton of *saxatilis* in illustrating the synonymy of the fish skeleton and with the exception of the trunk skeleton the same illustrations appeared in Jordan (1905: figs. 22–26 and 28). Excellent figures of the head skeleton are given by Gregory (1918: figs. 1, 2, 6, 7). He (1933: figs. 1 and 119) also discusses and illustrates the head skeleton in his monograph on fish skulls. Merriman's (1940: 55–64) fine paper describes the trunk skeleton of *saxatilis* and includes detailed drawings of the parts. Günther (1859: 66) described the skeleton of *americanus*, and a dorsal view of the skull of *labrax* appeared in Boulenger (1895: 125).

Terminology for the skull components follows Gregory (1933); that of the trunk skeleton is after Merriman (1940).

In the present study the skeletons of five species of *Roccus* are compared. Lack of readily available study material of *punctatus* precluded its use here.

Mitchill (1815: 415) refers to an aberrant form of *saxatilis* which has broken or interrupted stripes and applies to it the name *Perca mitchilli interrupta*. The *interrupta* of Mitchill is considered as a subspecific *nomen dubium* and therefore not as a senior homonym (see Copenhagen Decisions on Zoological Nomenclature 1953: 24) of *interrupta* (Gill, 1860).

Roccus is of masculine gender, viz. *americanus, interruptus* and *punctatus*.

Deep appreciation is expressed to the following persons. Dr. Edward C. Raney of Cornell University assisted in securing specimens and offered many helpful suggestions in the preparation of the manuscript. Drs. Howard E. Evans and John C. Ayers of Cornell University gave many useful criticisms. Dr. Reeve M. Bailey, University of Michigan, helped greatly with the generic nomenclature. Specimens from the U. S. National Museum were made available by Dr. Leonard P. Schultz and Dr. Ernest A. Lachner, curators. Dr. Royal D. Suttkus of Tulane University, Dr. Glen L. Gentry of the Tennessee Fish and Game Commission and Mr. Joe A. Chapman of Carson-Newman College provided many specimens used in the study. The illustrations were prepared by Dr. William C. Dilger and Mr. Rudolph J. Miller of Cornell University and Dr. Warwick R. West, Jr. of the University of Richmond.

SUBGENERA AND SPECIES

Roccus (Mitchill, 1814: 25; type species, *R. saxatilis*)

External characters: Dorsal fins separate. Anal soft rays 10–15 (usually 11–13). Lower jaw projecting beyond upper. Anal spines graduated. Spines in fins moderate, intermediate between *Morone* and *Dicentrarchus*.

[1] From a doctoral thesis in part, prepared under the direction of Edward C. Raney of Cornell University, 1955.

Osteological characters: Teeth present on base of tongue. Dentary strong with small sensory-canal pores. Otic region not greatly inflated. Preopercle serrate posteriorly and ventrally. Dentigerous surface of vomer intermediate between *Morone* and *Dicentrarchus* in antero-posterior width. Vertebral column straight or almost straight.

Roccus saxatilis (Walbaum, 1788: 330). Found along the Atlantic Coast of North America from the St. Lawrence River, Canada to the St. Johns River, Florida and in the Gulf of Mexico from northwest Florida to Lake Pontchartrain; successfully introduced on the Pacific Coast in the latter part of the 19th Century and now found in California and Oregon. Anadromous; spawns in fresh water in the spring of the year.

Roccus chrysops (Rafinesque, 1820: 22). Inhabits fresh water in the Mississippi River and Great Lakes drainages east to the St. Lawrence River. Spawns in the spring.

Morone (Mitchill, 1814: 16; type species, *Roccus americanus*)

External characters: Dorsal fins slightly joined at base. Anal soft rays 8–10 (usually 9–10). Lower jaw not projecting beyond upper. Anal spines not graduated. Spines in fins stout.

Osteological characters: Teeth absent on base of tongue. Dentary weak, with large sensory-canal pores. Otic region greatly inflated. Preopercle serrate posteriorly and ventrally. Dentigerous surface of vomer narrow anteroposteriorly. Vertebral column arched anteriorly.

Roccus americanus (Gmelin, 1789: 1308). Found in saline and fresh water habitats along the Atlantic Coast of North America from Nova Scotia to South Carolina; in fresh water as far inland as Lake Erie where recently arrived (Larson, 1954: 154) probably by way of New York Barge Canal. Spawns in fresh or slightly brackish water in the spring of the year.

Roccus interruptus (Gill, 1860: 118). Found in fresh water in the Mississippi River drainage where it is more abundant in the south. Spawns in the spring.

Dicentrarchus (Gill, 1860: 111; type species, *Roccus labrax*)

Description of external characters is based on specimens of *Roccus labrax* and from an analysis of *Dicentrarchus* in Jordan and Eigenmann (1890: 424) and Moreau (1881: 337).

External characters: Dorsal fins separate. Anal soft rays 11 or 12. Lower jaw projecting beyond upper. Anal spines graduated. Spines in fins very slender.

Osteological characters (based on *labrax*): Teeth present on base of tongue. Dentary strong with large sensory-canal pores. Inflation of otic region intermediate between *Morone* and *Roccus*. Preopercle serrate posteriorly and with large anteriorly directed spines on ventral margin. Dentigerous surface of vomer broad anteroposteriorly. Vertebral column straight.

Roccus labrax (Linnaeus, 1758: 290). Found along the coast of Europe from Norway to the Black Sea. Enters rivers occasionally. Spawns in early summer to fall in saline coastal waters; eggs are pelagic.

Roccus punctatus (Bloch, 1792: 64). Inhabits the Mediterranean Sea and the Atlantic Ocean from Senegambia to the Bay of Biscay (Meek, 1916: 293).

From the discontinuous distribution of the species of *Roccus*, it seems probable that the ancestral stock was at one time widely distributed in the North Atlantic Ocean. On the European side, it gave rise to the *Dicentrarchus* type which later divided into the species *labrax* and *punctatus*. Both have retained a close relationship with the sea.

In North America two primary branches evolved from the ancestral stock, each of which later diverged giving rise to a fresh-water and an anadromous form. The subgenus *Roccus* (*saxatilis* and *chrysops*) represents one line of evolution in North America, and the other is represented by *Morone* (*americanus* and *interruptus*).

Materials and Methods

Three methods were utilized in the preparation of materials: (1) dermestid beetles were used to clean skeletons, (2) preserved specimens were x-rayed, and (3) preserved specimens were cleared with KOH and stained with alizerine red S (Evans, 1948).

Specimens were aged by examination of the scales. Sex was determined by examination of the gonads. Fin-ray and gill-raker counts were made in a manner prescribed by Hubbs and Lagler (1947: 9, 13).

The specimens of *Roccus* included in this study are listed below. Data are listed in the

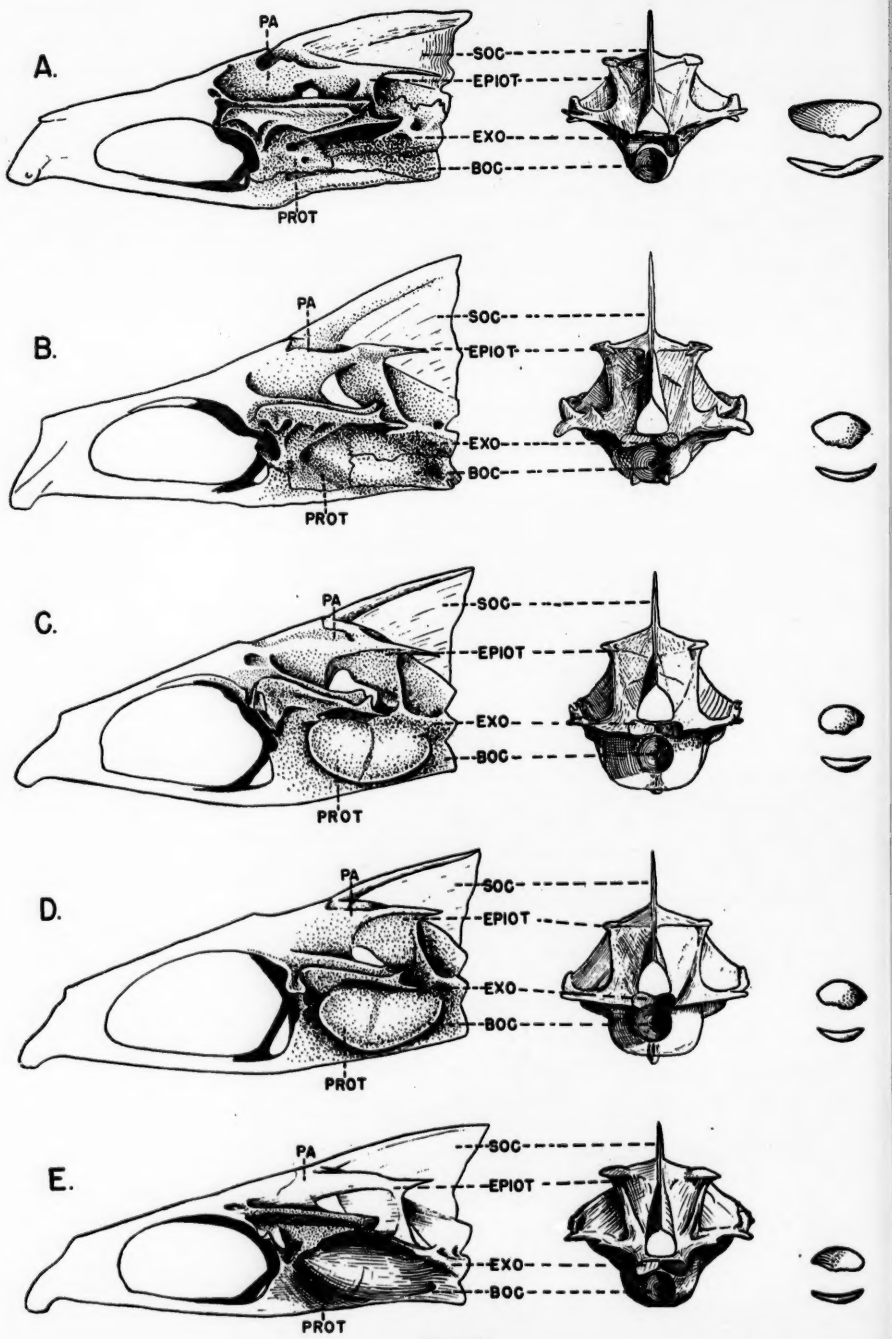

PLATE I

Skulls, lateral and posterior views; and otoliths, lateral and dorsal views of five species of *Roccus*. PA—parietal, SOC—supraoccipital crest, EPIOT—epiotic, EXO—exoccipital, BOC—basioccipital, and PROT—prootic. A, *saxatilis*: B, *chrysops*; C, *americanus*; D, *interruptus*; and E, *labrax*.

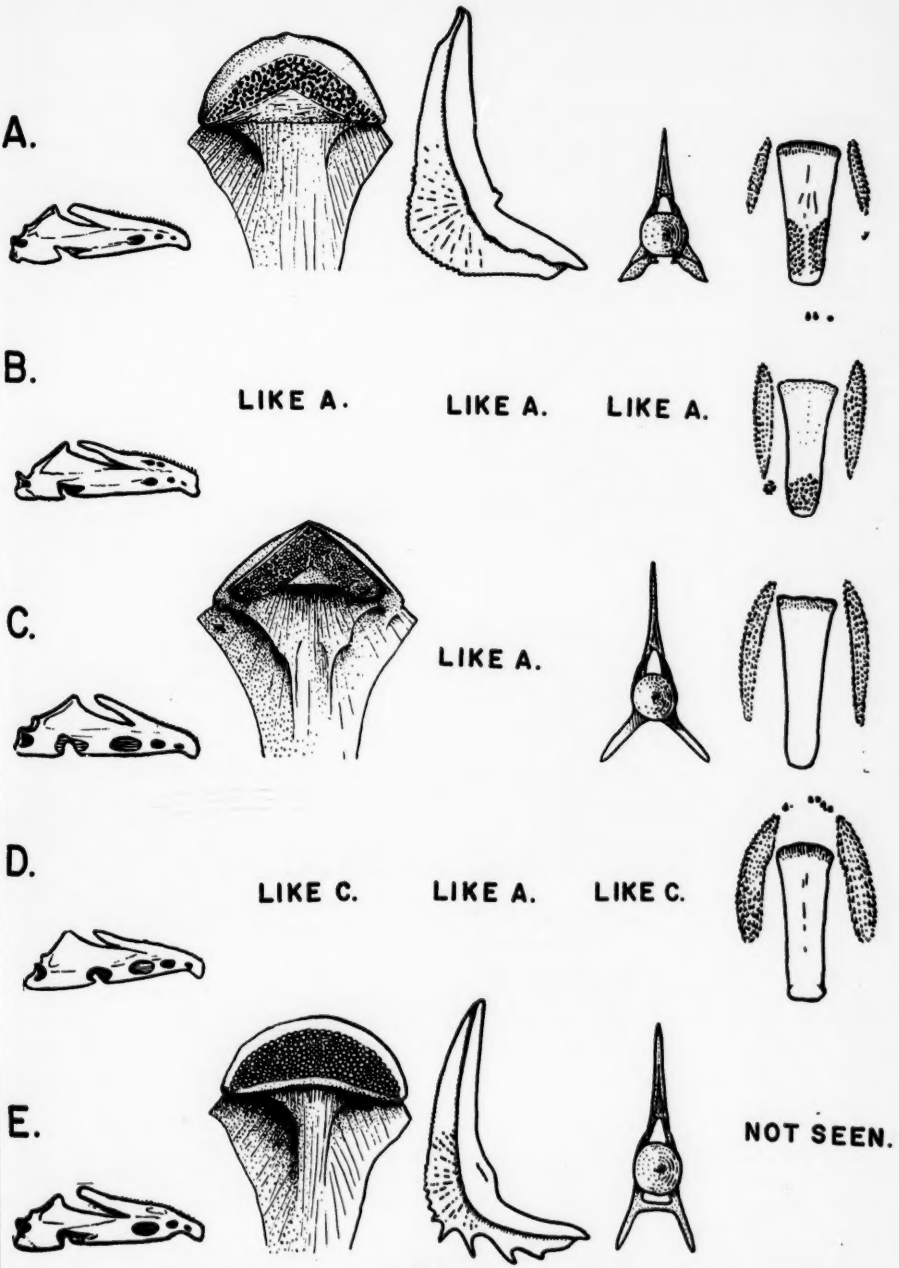

PLATE II

Diagnostic osteological characters of five species of *Roccus*. A, *saxatilis*: (left to right—lower jaw, lateral view; vomer, ventral view; preopercle, lateral view; tenth vertebra, anterior view; and glossohyal and lateral tooth bones, dorsal view. B, *chrysops*: lower jaw; and glossohyal and lateral tooth bones. C, *americanus*: lower jaw; vomer and tooth plate; tenth vertebra; and glossohyal and lateral tooth bones. D, *interruptus*: lower jaw; and glossohyal and lateral tooth bones. E, *labrax*: lower jaw; vomer; preopercle; and tenth vertebra.

following order: species; (in parenthesis) age range, range of standard lengths in millimeters; locality; number of specimens from each locality; and (in parenthesis) museum catalogue numbers. CU and USNM represent Cornell University and the United States National Museum respectively.

Roccus saxatilis. (0–11, 55–665). Hudson River, N.Y., 1 (CU 28526), 3 (CU 24028); Delaware River, N. J., 2 (CU 22004); Rappahannock River, Va., 3 (CU 23672); York River, Va., 1 (CU 26151); St. Johns River, Fla., 3 (CU 28525); and one specimen without data.

Roccus chrysops. (2–4, 115–220). Cherokee Lake, Tenn., 3 (CU 28522); Tennesse River, Tenn., 6 (CU 28523); Norris Reservoir, Tenn., 1 (CU 24005); Ouachita River, Ark., 1 (USNM 36440); Lake Ontario, N. Y., 1 (CU 28011).

Roccus americanus. (0–4, 52–135). Hudson River, N. Y., 2 (CU 26343), 3 (CU 28527); Delaware River, N. J., 1 (CU 22005); Patuxent River, Md., 3 (CU 23498); James River, Va., 1 (CU 23467); and one specimen without data.

Roccus interruptus. (2–4, 118–159). Lake Pontchartrain, La., 5 (CU 28524), 1 (CU 24082); Moon Lake, Miss., 1 (CU 13314); San Jacinto River, Texas, 1 (USNM 46262).

Roccus labrax. (2 and 3, 208–220). Greece, 1 (USNM 45016); Genoa, Italy, 1 (USNM 29755); France, 1 (USNM 21171).

With the exception of *labrax*, at least two skeletons of each species were disarticulated for comparative study. A total of 48 skeletons were examined; 27 cleaned, 10 x-rayed, and 11 cleared. Measurements of skeletal parts in millimeters were taken with dividers. Small specimens were examined under the low magnification (7× and 15×) of a binocular dissecting microscope. A change was noted with age in *saxatilis*; in an eleven year old specimen thickening and wrinkling of some bones was apparent. There was no evidence of sexual dimorphism in any of the examined skeletons.

Illustrations of the skulls and lower jaw (Pls. I and II) were prepared by Rudolph J. Miller. The vomerine bones (Pl. II) were drawn freehand by Warwick R. West, Jr. The remaining illustrations were made by William C. Dilger. The image of the otoliths and vertebrae were traced from a projection on the ground glass plate of a bellows type camera. The bones of the tongue are freehand drawings of cleared specimens made under a low power binocular microscope.

The following account applies to all five members of *Roccus* investigated except where individual species are mentioned. Diagnostic differences between species are summarized in the Table and illustrated in the Plates.

Osteological Comparisons

Neurocranium—The nasal is elongate, flattened, and encloses part of the supraorbital lateral-line canal. It articulates posteriorly with the dermethmoid and anteriorly it rests on the median dorsal tip of the maxilla. The ventral margin of suborbital-1 may or may not be serrate. A groove which contains the infra-orbital lateral-line canal extends through the five suborbitals. The third suborbital has an inward projecting shelf of thin bone that supports the eye. A pair of sclerotic bones of equal size lie embedded in the sclera of the eyeball.

The vomer has rows of villiform teeth on its ventral surface which form an obtuse angle in the American species. In *saxatilis* and *chrysops* the vomerine tooth plate is broader anteroposteriorly and the angle less acute than it is in *americanus* and *interruptus* (Tab. I and Pl. IIA, C). In *labrax* (Pl. IIE) the tooth plate is half-moon shaped and almost completely covers the ventral surface of the vomer.

Laterally a wing of the prefrontal projects to articulate with the mesial surface of suborbital-1. The large orbital opening which is elongate in *saxatilis*, *chrysops* and *labrax* is rather deep and short in *americanus* and *interruptus* (Pl. I).

R. saxatilis, *chrysops* and *labrax* are similar in that the frontal bone is heavy and has a relatively small sensory canal and small pores. In *americanus* and *interruptus* the frontal appears fragile because of the presence of the large sensory canal.

The supraoccipital crest is low in *saxatilis* and *labrax* and is high in the other three species (Pl. I). The mean and range, in parenthesis, of the percentages obtained by dividing the length of the crest into the height for five specimens follow: *saxatilis* 46% (37–52%); *chrysops* 68% (66–71%); *americanus* 71% (66–75%); and *interruptus* 75% (72–82%). In the single specimen of *labrax* the height was 53% of the length. The angle between the dorsal margin and the

TABLE I

DIAGNOSTIC OSTEOLOGICAL CHARACTERS OF FIVE SPECIES OF *ROCCUS*

Character	*saxatilis*	*chrysops*	*americanus*	*interruptus*	*labrax*
Vomer					
Dentigerous surface	Broad antero-posteriorly	Like *saxatilis*	Narrow antero-posteriorly	Like *americanus*	Like *saxatilis*
Angle formed by tooth rows	Obtuse	Like *saxatilis*	Like *saxatilis*	Like *saxatilis*	Half-moon shape
Frontal	Strong. Sensory canal and pores small	Like *saxatilis*	Relatively weak. Sensory canals and pores large	Like *americanus*	Like *saxatilis*
Supraoccipital crest					
Shape	Long and low	Short and high	Short and high	Like *americanus*	Long and low
Length divided by height	2.0-2.5	1.5	Like *chrysops*	Like *chrysops*	2.0
Angle formed by base and dorsal margin	30 degrees	40 degrees	50 degrees	Like *americanus*	35 degrees
Parietal	Not inflated	Inflated	Like *chrysops*	Like *chrysops*	Like *chrysops*
Otic region					
Area swollen	Mostly proötic	Proötic and basi-occipital	Proötic, basioccipital, and exoccipital greatly inflated	Like *americanus*	Intermediate between *chrysops* and *americanus*
Suture between proötic and exoccipital	Very irregular	Irregular	Entire	Like *americanus*	Irregular
Otolith (sagitta)					
Shape mesially	Strongly concave	Concave	Flat	Slightly concave	Concave
Width divided by thickness at center	4.5	4.0	2.3	3.0	2.3
Length divided by width	2.5	1.7	Like *chrysops*	Like *chrysops*	2.2
Opisthotic, posterior process	Extends posteriorly	Extends dorsally	Absent	Absent	Extends posteriorly
Maxilla	Serrate at posterior edge	Like *saxatilis*	Smooth at posterior edge	Like *americanus*	Like *americanus*
Lower jaw	Projects beyond upper jaw. Strong. Sensory canal and pores small	Like *saxatilis*	Not projecting. Frail. Sensory canal and pores large	Like *americanus*	Projects beyond upper jaw. Strong. Sensory canal and pores large
Opercle	Pronounced U-shaped notch just above hyomandibular articulation	Right angled indentation above hyomandibular articulation	Indentation absent	Indentation absent	Indentation absent
Preopercle, ventral margin	Serrate	Serrate	Serrate	Serrate	Spines (4 to 6)
Urohyal	Elongate (lateral view). Greatest depth near posterior tip. Trough lacks median ridge	Deeper than *saxatilis*. Greatest depth at ⅓ distance from anterior tip. Trough with median ridge	Like *chrysops* in shape. Median ridge in trough present or absent	Like *chrysops* in shape. Trough lacks median ridge	Elongate. Greatest depth at ⅓ distance from anterior tip. Trough lacks median ridge
Tongue					
Teeth on base of	Two parallel rows	Single patch	Absent	Absent	Single patch
Lateral tooth bone	Short and narrow	Long and elliptical	Long, narrow and slightly curved	Long, broad and curved	Tooth patches large and oval (bones not observed)
Dorsal pterygiophores	23	25	23	23 or 24	24
Anal pterygiophores	12	13 or 14	10	10	12
Epaxial procurrent rays	11	11	11	10	*
Hypaxial procurrent rays	11	9	9	7	*

TABLE I—*Cont.*

Character	*saxatilis*	*chrysops*	*americanus*	*interruptus*	*labrax*
Form of vertebral column	Straight	Slightly curved	Moderately curved	Moderately curved	Straight
10th vertebra	Haemal arch may be partially or completely formed	Like *saxatilis*	Haemal arch absent	Like *americanus*	Haemal arch formed
Angle described by sub-cleithrum from longitudinal axis of pectoral fin	45 degrees or less	Between 45 and 60 degrees	Greater than 60 degrees	Like *americanus*	80 degrees

* Not observed.

base line of the supraoccipital crest differs in the several species as follows: *saxatilis*, 30 degrees; *labrax*, 35 degrees; *chrysops*, 40 degrees; and in *americanus* and *interruptus*, 50 degrees. There seemed to be little variation with size and/or age.

The supraoccipital, exclusive of crest, and the parietal are slightly inflated in *chrysops*, *americanus*, *interruptus* and *labrax*; this gives a rounded appearance to the posterior region of the skull, unlike *saxatilis* (Pl. I). A slight crest is evident, especially in older specimens, on the dorsal portion of the parietal.

The epiotic has a posterior wing-like projection that extends beyond the body of the bone. This projection and the supraoccipital crest form a prominent surface for muscle attachment.

The pterotic bears a deep groove in which lies a sensory canal. A fossa on the ventral surface of the pterotic serves for the articulation of the posterior head of the hyomandibular. The fossa at the suture between the sphenotic and proötic serves for the articulation of the anterior head of the hyomandibular.

The alisphenoid is flattened posteriorly but thickened anteriorly so that at its ventro-anterior surface, which is in contact with the basisphenoid, it is very strong. The basisphenoid has a median brace which extends downward and rests against the parasphenoid and has two dorsal wings which contact the alisphenoid. In *saxatilis*, *chrysops* and *labrax* the basisphenoid is a more solid structure than in either *americanus* or *interruptus*. The parasphenoid has a dorsal trough and a ridge within, which extends from the anterior end to the basisphenoid junction. Differences in the shape of the parasphenoid cause considerable differences in the ventral profile of the neurocranium. In *chrysops* the ventral contour of the parasphenoid is practically straight; in *labrax*, *americanus* and *interruptus* it is moderately curved; and in *saxatilis* the contour has a relatively sharp angle below the proötic (Pl. I).

The otic region (proötic, exoccipital and basioccipital) is significant because the relationship of the species is clearly indicated (Pl. I) by a comparison of the shape and size of the component parts of the otic capsule and the otolith. The maximum distention of the otic capsule is found in *americanus*. In that species the proötic, exoccipital and basioccipital are thin-walled and greatly inflated; the suture shows no irregularity. The otic capsule is kidney shaped (Pl. IC); the otolith is thick and flat on the medial surface and conforms to the shape of the capsule (Table I). In *interruptus* the suture is practically identical to *americanus* and the swelling of the otic region is approximately the same. However, the otolith has a slight concavity on its medial surface. In *chrysops* the suture of the proötic and the exoccipital is irregular. The swelling is generally restricted to the proötic and basioccipital and results in a more ovate capsule. The otolith is concave mesially and is much thinner than that of *americanus* and *interruptus*. In *saxatilis* the suture between the proötic and exoccipital is strengthened by interdigitations. The otic capsule is less distended than it is in *chrysops* and barely protrudes beyond the surrounding bone. The otolith is curved greatly on the longitudinal axis and is relatively thin (Table I). The otic capsule of *labrax* is intermediate in shape and size between *chrysops* and *americanus*. Swelling occurs about equally in the proötic and the basioccipital while the exoccipital is scarcely affected. The suture between the proötic and exoccipital is slightly irregular whereas that between the proötic and basioccipital is straight. The otolith

is intermediate in width between *saxatilis* and *chrysops* and similar to *americanus* in thickness.

The opisthotic bears a projection on its posterior margin which points backward in *saxatilis* and *labrax*, and upward in *chrysops*; *americanus* and *interruptus* lack any such extension.

The exoccipital condylar surfaces differ somewhat in shape for each species (Pl. I).

BRANCHIOCRANIUM—The body of the premaxilla is slightly curved and bears villiform teeth. Each premaxilla has three dorsal processes; two are located anteriorly and the other about midway. The medial anterior process is long, pointed, and extends dorsally to the level of the vomer while the shorter lateral anterior process articulates with the anterior median portion of the maxilla. The third process of the premaxilla extends behind the maxilla and according to Gregory (1933: 241) prevents lateral dislocation of the premaxilla. The toothless maxilla extends beyond the posterior end of the premaxilla. Ventral and dorsal grooves at the anterior end of the maxilla serve as points of articulation with the premaxilla and palatine respectively. Posteriorly the maxilla is broadened dorso-ventrally and in *saxatilis* and *chrysops* the posterior edge may be serrulate. Serrae are absent in *americanus*, *interruptus* and *labrax*. In his illustration of *saxatilis* Gregory (1933: fig. 119) shows a small supramaxilla resting on the dorso-posterior edge of the maxilla, but although searched for this structure was not observed in this study.

R. saxatilis and *chrysops* have strong compact bones forming the lower jaw. The diameter of the sensory canal (Pl. II) is smaller than in the other species and the pores are small and elongate. In *americanus* and *interruptus* the lower jaw appears frail because of the large sensory canal and pores; this character may serve in separating young *americanus* from *saxatilis*. Although large sensory pores are present on the lower jaw of *labrax*, the bone appears to be much denser and less frail than in *americanus* and *interruptus*. The lower jaw projects beyond the upper in the older specimens of *saxatilis*, *chrysops* and *labrax* whereas in *americanus* and *interruptus* it is included.

The hyomandibular is thick centrally and tends to flatten toward the periphery. An anterior ventral process articulates with the metapterygoid, while a posterior ventral process rests between the leading edge of the preopercle and the rear edge of the metapterygoid. A cartilaginous pad separates the hyomandibular from the symplectic.

The suture between the epihyal and ceratohyal is fused except in the center. Along the ventral surface are located the seven branchiostegals; five are attached to the ceratohyal and two on the epihyal. The glossohyal, the most anterior of the hyoid series, is small and elongate with a widened anterior portion. At its base two rows of small teeth appear in *saxatilis*; an oval patch of teeth is present in *chrysops* and *labrax*; and teeth are lacking in *interruptus* and *americanus* (Pl. II).

On either side of the glossohyal is a very small bone that bears teeth (Pl. II). These are observable only in cleared and stained specimens. The shape of the bone varies with the species. In *saxatilis* it is narrow and elongate and extends only a slight distance beyond the tip of the glossohyal. In *chrysops* it is similar in shape to *saxatilis* but is larger; in addition there is a second small tooth patch situated posterior to the left bone. In *americanus* it is elongate, tends to curve slightly, and extends somewhat beyond the tip of the glossohyal. In *interruptus* the bone is broad, slightly curved, and extends well beyond the anterior end of the glossohyal. The lack of cleared specimens prevents a description of the lateral tooth bone in *labrax*. However, the tooth patch is large and ovate in shape. In the cleared material only *chrysops* and *interruptus* had teeth on the tip of the tongue (Pl. II, Figs. B and D), but an examination of preserved specimens revealed that teeth are occasionally present in all of the species studied.

At the anterior end of the urohyal are two heads; one is free and the other, dorso-anterior, articulates with the first basibranchial. In all species studied the posterior ventral aspect of the urohyal is grooved. The groove is smooth in *saxatilis*, *labrax* and *interruptus*, but in all specimens of *chrysops* and in two of seven specimens of *americanus* examined it contained a thin median ridge. The depth enters the length of the urohyal 2.7 times in *saxatilis*, 3 in *labrax*, and 2.5 in the other species.

The entopterygoid is a large flat bone which projects inward to form a lateral roof for the oral cavity. The palatine tapers to a point posteriorly; anteriorly it has a forward extension

which rests on the head of the maxilla. The ventral surface of the palatine bears teeth.

The preopercle in *labrax* is narrow anteroposteriorly, serrate at its posterior margin, and has large antrorse spines on its ventral margin. In the other species studied it is broad anteroposteriorly and is serrate along the posterior and ventral margins (Pl. II). The small process shown at the anterior angle of the preopercle in *saxatilis* (Pl. IIA) is prominent only in older specimens; in younger specimens of *saxatilis* and in the other three species the condition is similar to that of *labrax*. The anterior margin contains a portion of the lateral-line canal which in *americanus* and *interruptus* is large and which gives the bone a weak appearance.

The posterior margin of the opercle bears two spines, the lower being stronger. In *saxatilis* a prominent U-shaped notch occurs at the upper third of the leading edge of the opercle just above its articulation with the hyomandibular. In *chrysops* there is a right-angled indentation above the point of articulation with the hyomandibular, but the edge remains entire to the dorsal margin of the bone. In *americanus*, *interruptus* and *labrax* the edge is entire to the dorsal border. The thin flat subopercle at its anterior dorsal edge is overlapped somewhat by the opercle, and a dorsal projection adds strength to its articulation with the opercle.

The gill arches are five in number; the first four bear gill rakers and lamellae whereas the fifth is greatly modified for tooth attachment. Two rows of gill rakers are present on each of the first four arches. In the few counts made of the long rakers on the outer row of the first arch, a trend was noted toward a higher number in the more marine species: 20–25 in *saxatilis*, 20–24 in *chrysops*, 19–22 in both *americanus* and *interruptus*, and 23–25 in *labrax*.

The epibranchials which form the lateral roof of the gill chamber join the ceratobranchials ventrally and the pharyngobranchials dorsally. There are only three pharyngobranchials; the first two ceratobranchials articulate with the first pharyngobranchial. The surface of the pharyngobranchials is heavily toothed.

TRUNK SKELETON—Characteristically the number of vertebrae in *saxatilis* is 25 (12 + 13) including the hypural vertebra. In rare instances specimens may have only 24 vertebrae. Vladykov and Wallace (1952: 148) examined 2,500 specimens of *saxatilis* from Chesapeake Bay and found only one fish with 24 vertebrae. *R. chrysops*, *interruptus*, and *labrax* in the relatively small samples counted have the same number as *saxatilis*, but *americanus*, which usually also has 25, had only 24 (12 + 12) in two of ten specimens counted.

In all species the haemal arch is completely formed at the eleventh vertebra. In *saxatilis* and *chrysops* the haemal arch on the tenth vertebra may be complete or partially formed. In *labrax* the tenth vertebra had a complete haemal arch (Pl. II).

The vertebral column in *saxatlis* and *labrax* is straight while in the other three species it is arched. The degree of curvature gradually increases from *chrysops* through *americanus* to *interruptus*. The arch in the vertebral column parallels the contour of the dorsal profile of the species, as is evident from the almost straight profile in *saxatilis* to the highly arched back of *interruptus*.

There are 12 pairs of pleural ribs in all of the species. The first two are relatively small while the following ten ribs are large and decrease in size posteriorly. While the first three pairs of ribs are attached to their vertebral centra, the remaining ribs articulate with parapophyses.

Epipleurals, small accessory ribs, are attached to the outer surfaces of pleural ribs three through seven. There are five pairs in the species studied which is at variance with Merriman (1940: 61) who gave four pairs of epipleurals for *saxatilis*. The attachment of the epipleural rib to the pleural rib is delicate and the epipleurals are easily lost; they should be counted in cleared specimens.

Merriman (1940: 61) discusses and illustrates the caudal skeleton of *saxatilis*, and except for number of epaxial and hypaxial rays this study corroborates his findings. All species have 17 caudal rays which are branched except for the marginal rays. In the cleared specimens the number of epaxial and hypaxial procurrent elements were counted as follows: *saxatilis* 11 + 11, *chrysops* 11 + 9, *americanus* 11 + 9, and *interruptus* 10 + 7. Since many of the small rays are not exposed, they are easily overlooked if only cleaned skeletal material is used. For *saxatilis* Merriman (1940: 61) mistakenly lists only seven epaxial and four hypaxial rays, but in all probability he used cleaned specimens. The remaining caudal skeletal elements are essentially the same for all five of the species.

Dorsal pterygiophores modally number 25 in *chrysops*, 24 in *labrax*, and 23 in *saxatilis*, *americanus*, and *interruptus*. The difference is correlated with the dorsal fin-ray elements in each species; *chrysops* has the largest number, normally with a total of 25–26 rays. In all species of *Roccus* the first three dorsal pterygiophores precede and do not support the dorsal fin. In *saxatilis* the fourth pterygiophore usually extends ventrally between the third and fourth neural spines but may be located between the second and third neural spines. In the other four species the fourth pterygiophore is situated between neural spines two and three with the exception of one out of three specimens of *labrax* which is like *saxatilis*. In *americanus* and *interruptus* a pterygiophore is missing between neural spines 10 and 11. Two pterygiophores, numbers 13 and 14, are found in the space between neural spines 11 and 12. Usually each ray of the dorsal fin is supported by a single pterygiophore. However, the first two spines of the first dorsal fin are supported by pterygiophore number four and sometimes the last two rays of the second dorsal are supported by the last pterygiophore. On an x-ray plate the fourth pterygiophore appears to be composed of two elements with two separate centers of ossification. Possibly, as Gregory (1918: 7) suggests, a fusion of two pterygiophores has occurred and has resulted in a much stronger support.

The ventral pterygiophores differ between species as did the dorsal pterygiophores. Again *chrysops* with its large number of total anal-fin rays, 15–16, has either 13 or 14 anal pterygiophores, *saxatilis* and *labrax* have 13–15 anal rays and 12 pterygiophores, and both *americanus* and *interruptus* have 11–13 anal rays and 10 pterygiophores. A comparison of the pterygiophores and anal-ray count in each species shows the close correlation. All species have three anal spines, but on rare occasions four are observed in *saxatilis*, and despite the statement by Merriman (1940: 60) in reference to the illustration in Starks (1901: pl. 56) that four spines are never found, four spines have been counted in three specimens. Two of the counts of four spines were from a sample of 23 and one from a sample of 11.

The first ventral pterygiophore is located between the haemal spines of the last abdominal and the first caudal vertebrae and supports the first two spines of the anal fin. The first anal pterygiophore is large like the fourth dorsal pterygiophore. The second pterygiophore articulates with the third spinous ray and each soft ray is supported by a single pterygiophore, with the exception of the last two rays which are supported by the last pterygiophore. Although there is some variation within a species as to the exact location of each ventral pterygiophore relative to the haemal spine, in all species the pterygiophores fall between the second and seventh haemal spines.

The anterior end of the arrow-shaped pelvic girdle lies in the cradle formed by the left and right cleithral bones of the pectoral girdle. The pelvic fin has a constant number (five soft, one spine) of rays.

The pectoral girdle has two post-cleithra, a superior and an inferior; the latter is overlapped somewhat by the superior's ventral surface as was described by Merriman (1940: 56). Apparently the only difference which exists between the species studied for this region of the skeleton is found in the angle of the inferior postcleithrum from the long axis of the pectoral fin. The inferior post-cleithrum in *saxatilis* is elongate, projects posteriorly and ventrally at less than a 45 degree angle from the longitudinal axis of the pectoral fin. In *chrysops* the angle is greater than 45 degrees but never more than 60 degrees; in *americanus* and *interruptus* the angle is greater than 60 degrees, usually between 70 and 80 degrees, and in *labrax* it was 80 degrees. From 14 to 18 pectoral rays are found in all of the species.

Summary

The number of skeletons used in the study was: *saxatilis* (14), *chrysops* (12), *americanus* (11), *interruptus* (8), and *labrax* (3). Preserved specimens were x-rayed and cleared and stained. Others were cleaned by dermestid beetles.

Skeletal parts were compared by observation and measurement; some parts were counted. The species studied are similar in most skeletal characters and where differences occur, intergrading forms are usually found between the extremes. With the exception of *americanus* and *interruptus* the species are readily separated using osteological characters. The evidence strongly supports the monogeneric classification

of Jordan and Gilbert (1883: 528–531) and Berg (1949: 1012–1013). To define subgenera both osteological and external characters are needed. The outstanding differences are as follows:

1. The vomerine tooth plate in *labrax* is extensive and almost completely covers the ventral surface of the vomer; in *saxatilis* and *chrysops* the plate is less broad antero-posteriorly but is broader and less acutely angled than that of *americanus* and *interruptus*.

2. Teeth are absent on the base of the tongue in *americanus* and *interruptus*; an oval tooth patch is present in *chrysops* and *labrax* and there are two rows of small teeth in *saxatilis*.

3. The supraoccipital crest is lower in the more marine species, *labrax* and *saxatilis*, and conforms to the elongation of the body.

4. The otic region clearly indicates the relationship of the species. In *americanus* and *interruptus* it is greatly swollen and the otolith is thick; in *labrax* it is less swollen and the otolith is thinner; in *chrysops* and *saxatilis* it is little inflated and the otolith is thin.

5. The lower jaw is frail with a large sensory canal and pores in *americanus* and *interruptus*; in *labrax* the pores are large but the jaw appears strong due to the denser bone; in *chrysops* and *saxatilis* the lower jaw is compact and both the canal and pores are small.

6. The parietal is somewhat inflated in all except *saxatilis*.

7. The opercle bears a pronounced U-shaped notch just above the point of articulation with the hyomandibular in *saxatilis*; in *chrysops* it is indented but in the other species it is entire to the dorsal margin. In *labrax* the ventral margin of the preopercle has four to six strongly developed spines and in the other species it is serrate.

8. The number of dorsal pterygiophores is greatest in *chrysops*. Their location with regard to the position of the neural spines will separate all species.

9. The haemal arch on the tenth vertebra was absent in *americanus* and *interruptus*, was sometimes present in *saxatilis* and *chrysops*, and was present in *labrax*.

10. The angle formed by the inferior postcleithrum and the longitudinal axis of the pectoral fin varies significantly being least in *saxatilis* and greatest in *americanus*, *interruptus* and *labrax*.

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A Comparison of Liver and Muscle Lipids in Arctic Fishes[1]

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THE chemical composition of fish tissues, especially with respect to the lipids of liver and muscle, has been widely investigated. A few of the more comprehensive works in this field are those of Bloor (1943), Jacobs (1944), Hilditch (1947) and Lovern (1951). However, few values are given for total fatty acid, cholesterol, and phospholipid content. Further information concerning these tissue constituents is necessary for a thorough development of concepts in the comparative biochemistry of fish lipids.

The purpose of this investigation is to provide additional quantitative data of the concentrations and ratios of these lipids in fishes, particularly inhabitants of arctic waters.

METHODS AND MATERIALS

Alaskan freshwater Blackfish, *Dallia pectoralis* Bean, were collected in Bethel, Alaska, and readily maintained in the laboratory aquaria at 20°C ± 5°C. Specimens were fed insect larvae, crustaceans, and other animal products. The three marine species used in this investigation were collected in the vicinity of Point Barrow, Alaska. Polar tomcod, *Boreogadus saida* (Lepechin), were collected both in summer and winter. Capelin, *Mallotus villosus* (Muller), were collected during spawning activities (August) on the beaches and in shallow tidal pools. Sculpin, *Myoxocephalus quadricornis* (Linnaeus) were collected off shallow beaches. The sculpins used in this investigation were small in size and readily recognized as immature forms.

All the fish, with the exception of the blackfish, were sacrificed immediately after collection and pieces of tissue excised. Identifications are according to Walters (1955). The tissues were weighed, put into an ethanol-benzin (3:1) mixture, and ground with powdered silica according to Bloor (1929). Cholesterol and total fatty acids were estimated using Bloor's methods (1916 and 1947) with Snell and Snell's modifications (1937). The Youngburg and Youngburg (1930) method was used for lipid phosphorus.

Phospholipid values are expressed as lipid phosphorus content × 25. Total lipid values are expressed as the sum of total cholesterol and fatty acids in a given tissue sample.

RESULTS

The data derived from the lipid analysis and from the ratios of concentrations of the lipids, one to another, are presented in Table I. It was found that the lipid content of the capelin (*M. catervarius*) liver is about twice that of the muscle. Capelin muscle is particularly low in cholesterol. A comparison of the lipid values from liver of tomcods (*B. saida*) collected in winter and summer showed significant differences in concentrations for each fat component. "t" values held to be significant at or beyond the 0.05 probability level are as follows: cholesterol, 2.44; phospholipid, 11.52; total fatty acids 4.35; total lipids, 4.24 and C/FA × 100, 2.54. The data in Table I show that there is considerable difference in lipid content between

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TABLE I

Liver and Muscle Lipid Values for Various Species of Arctic Fishes

Values are expressed as percentages of fresh tissue. Means and standard error of the means are given.

Species and number	Cholesterol	Phospholipid	Total fatty acids	Total lipid	C/LP	C/FA × 100
M. catervarius (12)						
liver	0.130	2.49	4.67	4.810	1.40	3.0
	0.014	0.48	1.37	1.381	0.34	0.69
muscle	0.026	1.238	2.06	2.087	0.56	1.2
	0.004	0.278	0.68	0.730	0.19	0.66
B. saida (12)						
(winter)						
liver	0.672	3.01	2.96	3.632	0.56	29.1
	0.197	0.62	1.33	1.707	0.11	13.8
muscle	0.367	1.67	4.32	4.680	5.4	8.8
	0.083	0.38	1.46	1.519	0.95	2.2
(summer)						
liver	1.310	0.36	8.14	9.451	—	16.3
	0.881	0.50	3.91	4.251	—	10.7
D. pectoralis (13)						
liver	0.962	0.76	3.29	4.253	36.1	28.9
	0.697	0.34	2.06	2.702	24.4	15.1
M. quadricornis (12)						
whole carcass	0.86	0.084	3.21	4.00	—	29.3
	0.16	0.303	1.19	1.18	—	12.7

a given tissue in the various species studied, and a seasonal difference in liver lipid content in the tomcod.

DISCUSSION

Each of the four species has some features worthy of elaboration. The capelin has low liver and muscle cholesterol and comparatively high phospholipid content. The view that a large amount of phospholipid in a tissue indicates a high rate of fat turnover (Bloor, 1943), would seem to hold true in the liver and muscle of the spawning capelin. In addition, the total liver lipid, 4.8% of fresh tissue, may be considered rather low by comparison with values recorded for other species (Hilditch, 1947). When the evidence is evaluated, the studies of *M. catervarius* suggest that, as a result of migration and spawning, there is a depletion of liver and muscle lipids as the result of a high level of fat turnover. Coincidently, this line of reasoning is in keeping with the results and interpretation of Greene (1926) who has reviewed the physiology of spawning migration.

There is an apparent seasonal variation in the liver of the tomcod: a high lipid content in summer and a low in winter. By contrast, Leim (1943) reported the increase of fat content to as much as ⅓ of the body weight in sardine herring during the winter. The high liver fat content of the summer-collected tomcod may represent a storage of lipid as the result of accelerated feeding due to the increased availability of food during the summer months, when the northern waters become abundant in plankton.

The blackfish is compared with the northern pike, *Esoc lucius* (Wilber, 1955), in view of the fact that they are probably the only northern fresh water fishes wherein similar studies have been made. The liver cholesterol content of *Dallia pectoralis* is remarkably close to that of

E. lucius, 0.96 and 0.89% respectively. By contrast, liver phospholipid and total fatty acid values of the blackfish are considerably lower than those reported for the pike.

Another comparison that can be made between two arctic fishes is the carcass total lipid from the sculpin and the stickleback (Wilber and Del Pomo, 1949). In the sculpin about 4.0% of the fresh body weight is in the form of lipid. In the stickleback about 5.0% is lipid. These values from both fishes are therefore comparable.

Mayer and Schaeffer (1913, 1914 a and b) have shown that the ratio of one lipid to another is fundamentally significant. They hold, for example, that the ratio of cholesterol to lipid phosphorus (C/LP) indicates the capacity of a tissue to imbibe or hold water. If this contention is valid, it can be seen in Table I that there is no consistent pattern in the relationship of lipids and water in tissues of the species studied. Mayer and Schaeffer found the ratio cholesterol/fatty acid (C/FA) to be constant in a given tissue from a number of animals of diverse species. Again, there is an obvious lack of similarity in the C/FA × 100 ratios (Table I).

It is evident from the ratio studies that these arctic forms do not fit in with many of the original generalizations made by Mayer and Schaeffer. Moreover this is in keeping with our view that there is practically no uniformity in the lipid patterns in the species studied. Generalizations concerning tissue composition and adaptability to arctic rigors cannot be made.

Summary

Tissue fatty acids, cholesterol and phospholipid were estimated in four Alaskan fishes, *Mallotus catervarius* (marine), *Dallia pectoralis* (fresh water), *Boreogadus saida* (marine) and *Myoxocephalus quadricornis* (marine-littoral). Evidence is presented which indicates a high level of fat turnover in liver and muscle of the spawning capelin, *Mallotus catervarius*. There is an apparent seasonal variation in the liver lipid content of the tomcod, *Boreogadus saida*, especially higher liver total lipid content in the "summer" tomcod.

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Predominance of the Young among Marine Fishes Found in Fresh Water

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INTRODUCTION

WHILE making a list of the euryhaline fishes of North America (Gunter, 1942), I gained the impression that marine fishes which invade fresh water are chiefly the young. Two men of considerable authority in ichthyological circles, Dr. C. M. Breder, Jr. and the late Dr. Samuel F. Hildebrand, independently made the same observation. Doctor Breder, in a letter dated January 21, 1938, stated that he acquired the general impression in Panama that there was "an intrusion of small marine fishes into fresh water." In a letter dated August 20, 1945, Doctor Hildebrand affirmed this view, stating, "... your observations and Dr. Breder's, relative to young fish ascending streams and entering fresh water to a greater degree than their adults is entirely in conformity with mine. My observations were made principally at Beaufort, N. C., during a residence there of about 10 years. Off hand, I think of flounders, soles, tonguefish, spot and croakers, all found at times in fresh water or nearly fresh water where their adults were not seen."

EVIDENCE FROM THE LITERATURE

Several instances of small marine fishes in fresh water have been recorded. My perusal of the literature has been confined to certain publications concerned with North and Middle America, except for that of Seely (*vide infra*). Length data on the same species taken from both fresh and salt water, at the same time in neighboring localities, are scarce.

Baird (1855) took several specimens of *Lutianus griseus* (Linnaeus), the gray snapper, about three inches long, from the Tuckahoe River. He listed them as *Lobotes emarginatus*. Fisher (1891) recorded a young cobia, *Rachycentron canadus* (Linnaeus), 95 mm. long, from the Croton River, a tributary of the Hudson. Evermann and Marsh (1900) took two tripletails, *Lobotes surinamensis* (Bloch), in Puerto Rico. "The smaller was taken by seine at the mouth of the Rio Bayamon at Palo Seco, in water very nearly fresh; ..." Meek (1904) recorded a mullet, *Mugil cephalus* Linnaeus, from fresh water at Tehuantepec, Mexico. It was five inches long. Meek (1908) recorded the snapper, *Lutianus argentiventris* (Peters), from fresh water in Mexico in the following words: "One small specimen taken in fresh water." It was 70 mm. long. Meek (1914) listed several species of marine fishes from the fresh waters of Costa Rica. The smaller size lengths given were: *Centropomus pectinatus* Poey, 93 mm.; *Gerres brevimanus* Günther, 50 mm.; *Eucinostomus californiensis* (Gill), 63 mm.; and *Achirus fonsecensis* Günther, 30 mm. The last species may live mostly in fresh water. Of 123 specimens of these four fishes taken in fresh water, the largest was 285 mm. long. Meek and Hildebrand (1923) stated that 22 small specimens of *Pritis pectinatus* Latham were taken, nearly all in fresh water, in Panama and that no large ones were seen. Hildebrand (1925) took several small specimens of *Centropomus robalito* Jordan and Gilbert, measuring from 120 to 140 mm. in length, from Rio Tempa, El Salvador. Meek and Hildebrand (1938) took 16 *Achirus mazatlanus* (Steindachner), 25 to 70 mm. long, in the fresh waters of Panama. Twenty-five *A. fluviatilis* Meek and Hildebrand taken in the same waters ranged from 25 to 50 mm. in length. These last two species may not be marine. Breder (1929) says *Trinectes maculatus* (Bloch and Schneider) enters fresh water especially when young.

Breder (1927) found the Rio Chucunaque of Panama marked by extensive intrusion of marine forms comprising nearly one-third of the species in the lower reaches with tidal reverses in flow, "although it is entirely fresh so far as we could determine." Most of the marine specimens he took in the Rio Chucunaque were small. A list of the species and their sizes are given in table (see top page 14).

Concerning the sawfish, *Pristis microdon* Latham, Breder says, "Only small examples were found and conversation with the natives failed to reveal a knowledge of large specimens. The innumerable 'saws' seen at the villages were all from fish of about the size taken."

Hildebrand and Cable (1930: 424) state: "Young spots also ascend brackish water

Species	Number	Range, mm.
Pristis microdon	8	770–965
Syngnathus elcapitanense	2	70–134
Anchovia curta	42	22–46
Mugil curema	87	25–122
Centropomus unionensis	101	17–120
Stellifer furthii	4	24–32
Stellifer melancheir	1	38
Ilisha furthii	39	18–43
Gobius daguae	1	59
Microgobius miraflorensis	280	14–34
Citharichthys gilberti	2	35–37
Achirus panamensis	2	25–30

ditches to fresh water during the spring and early summer." The species is *Leiostomus xanthurus* (Lacépède). These authors say in reference to *Paralichthys dentatus* (Linnaeus) and *P. albiguttus* Jordan and Gilbert, "In the light of our present limited information, it seems probable that the larger young may live principally in the brackish and fresh water creeks and ditches." Ginsburg (1932) acquired eight specimens of *Gobionellus shufeldti* (Jordan and Eigenmann), 27 to 40 mm. long, from the Sampit River, Georgetown, South Carolina, which were too small to show the characteristic appearance of the species. Gunter (1938) recorded a small specimen of *Trinectes maculatus* 160 miles upstream in the Atchafalaya River in Louisiana. It was 58 mm. long. Concerning this species Hildebrand and Cable (1938: 630) state: "It generally may be secured in numbers in the estuary of the Newport River in Beaufort, and the young especially range in abundance up the river into fresh water.

"Small examples of this sole sometimes are taken in fresh water far from the sea. For example, it is a more or less permanent resident, at least during the summer, of the Potomac River as far up as Washington. The senior author also has seen a small specimen taken in the Savannah River at Augusta, Ga., slightly more than 200 miles from the sea, following the course of the river. He also has a specimen from the Pascagoula River, taken at Merrill, Miss. . . ."

Hildebrand (1938) took four *Centropomus robalito* Jordan and Gilbert, 80 to 125 mm. long, in fresh water. Dill (1944) reported that large mullet, *Mugil cephalus*, do not seem to be common in the Colorado River in California. In early 1942 the population was composed wholly or mostly of juveniles. He stated that mullet in the Salton Sea grew to a much larger size. Seeley (1886) says concerning *Mugil capito* (Cuvier), the European grey mullet, "It spawns about Midsummer in the sea; and in August the young, which are then about an inch long, are seen entering fresh waters." Without listing the sizes Massman (1954) lists only the young of the following species from fresh water in Virginia: *Brevoortia tyrannus* (Latrobe), *Cynoscion regalis* (Bloch and Schneider), *C. nebulosus* (Cuvier and Valenciennes), *Bairdiella chrysura* (Lacépède), *Leiostomus xanthurus* (Lacépède), *Micropogon undulatus* Linnaeus and *Trinectes maculatus* (Bloch and Schneider).

Six papers were found which gave comparable data on the size of fishes in fresh and salt water. Evermann and Marsh (1900) and Dill (1944) have already been cited. Hubbs (1936) gave lengths of two species taken at the mouth of the Rio Champoton, Campeche, and on the beach nearby in brackish and salt water and also 34 kilometers upstream in pure fresh water. Hildebrand (1938) states that the waters of the Gatun and Miraflores Locks are slightly brackish, but the waters of the Pedro Miguel Locks are fresh. He took several species in both fresh and brackish water and gave their lengths. The data from these papers are summarized in Table I.

The above records prove that many small marine fishes invade fresh water and they indicate that the average size of the fresh water invaders is generally smaller than that of populations of the same species of nearby salt water. They are not to be taken as proving large marine fishes do not enter fresh water. The writer (Gunter, 1938) has given records of large mullet and large sharks in fresh water, and large marine fishes in fresh water, or practically fresh water, have been recorded by other authors. Among the sharks, especially, large specimens are known to enter fresh water. Massman (1954) divides the marine fishes commonly found in Virginia fresh waters into two groups, those found there only as young and those found there both as adult and young, but it may be significant that the latter group is composed of small, shore fishes.

TABLE I

LENGTHS OF SEVERAL SPECIES OF FISHES TAKEN IN FRESH AND SALT WATER IN NORTH AND MIDDLE AMERICA

Authors	Species	Number (in Parentheses) and Length Range	
		Fresh Water	Brackish or Salt Water
Evermann & Marsh (1900)	*Lobotes surinamensis*	(1) 6.5 in.	(1) 8 in.
Meek & Hildebrand (1928)	*Trinectes maculatus*	(1) 30 mm.	(1) 165 mm.
Hubbs (1936)	*Strongylura scrutator*	(2) 114–170 mm.	(5) 315–330 mm.
Hubbs (1936)	*Eucinostomus pseudogula harengulus*	(2) 19–20 mm.	(20) 25–57 mm.
Hildebrand (1938)	*Anchovia spinifer*	(many) up to 160 mm.	(many) 33–165 mm.
Hildebrand (1938)	*Mugil curema*	(3) 41–44 mm.	(27) 24–235 mm.
Hildebrand (1938)	*Centropomus robalito*	(4) 80–125 mm.	—
Hildebrand (1938)	*Lutianus novemfasciatus*	(1) 335 mm.	(1) 395 mm.
Hildebrand (1938)	*L. colorado*	(3) 339–580 mm.	(many) 150 mm. to several pounds "mostly large"
Hildebrand (1938)	*Pomadasys bayanus*	(2) 27–50 mm.	(2) 250–310 mm.
Hildebrand (1938)	*Cynoscion albus*	(3) 153–305 mm.	(7) 235–310 and some up to 30 in. (762 mm.) present
Hildebrand (1938)	*Achirus fluviatilis*	(5) 19–34 mm.	(1) 50 mm.
Dill (1944)	*Elops affinis*	(3) 8.5–9.8 in.	Those from Salton Sea reported 17 to 20 in.
Dill (1944)	*Mugil cephalus*	"juveniles"	Salton Sea "grew to a much larger size"

RELATION OF SALINITY TO SIZE OF MARINE FISHES ENTERING FRESH WATER

Several writers have shown that young marine invertebrates go far up into brackish water in contrast to the adults which are found in saltier water. The same thing holds for fishes, and Gunter (1945) gave an extended discussion of this phenomenon. It was shown that among 22 species of fishes those taken in water of lower salinity were smaller than those taken in saltier water. Several species showed direct relationship between salinity and size. The fact relevant to the proposition under consideration is that marine fishes in brackish water are of smaller size than fishes of the same species in saltier water. This does not mean that the very smallest animals are taken in the freshest water. "Small specimens, but not necessarily the smallest sizes, of several fishes enter the bays" (Gunter, 1945: 113). Most bay animals spawn in waters of high salinity in or near the sea and the young, as larvae, move into waters of lower salinity. This is the common pattern of life history and it results in the very smallest animals being found in waters of quite high salinity. Following their statement that small spots, *Leiostomus xanthurus*, invade fresh water, *vide supra*, Hildebrand and Cable (1930, p. 424) added, "Fish found in such an environment generally are larger than those found among vegetation in saltier water", but fish found in the deeper parts of Beaufort Harbor (still saltier water) were larger than either of the two other groups.

To avoid confusion it should be stated that such differential size distribution of fishes as related to salinity is a result of the life history cycle, and is not due to separate populations of fishes living in waters of different salinities (see Gunter, 1945: 115), such as occurs in *Cottus asper* and *Mollienesia latipinna*.

If the smaller sizes of marine fishes occur in greater numbers than the larger sizes of the same species in brackish and estuarine waters, it

follows that marine fishes entering fresh waters from the adjacent weakly saline waters would average smaller than fishes of the same species living in salt water. This inevitably holds true, unless the larger marine fishes migrate quickly through the lower salinities into fresh water. Except for certain anadromous species, the latter situation does not generally hold.

The fact that many young marine fishes and other animals have a greater predilection for entering and living in brackish and fresh waters than their older congeners, raises several questions relating to physiology and ecology. The physiological differences of young and old animals must be considered in connection with the relations of marine animals to the salinity of the environment.

Summary

Certain ichthyologists have independently noted in the field that marine fishes which enter fresh water, excluding anadromous species, are generally smaller than their congeners in salt water. Data from the literature show that many small marine fishes invade fresh water and that they are smaller than the same species in adjacent salt waters. Marine fishes in low salinities are smaller than those of the same species taken in saltier water. Since the fresh water invaders come from the population found in the slightly saline waters, the fishes invading fresh water are smaller in size than those in salt water. Differences in the relations of young and old animals to salinity of the water must be taken into account in studies of euryhalinity.

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New Records of Labrador Fishes with Special Reference to those of Hebron Fjord[1]

MALCOLM S. GORDON AND RICHARD H. BACKUS

THE Labrador cruises of the R/V BLUE DOLPHIN during the summers of 1952 and 1954 resulted in fish collections containing new distributional data for a number of species. These collections also provide new information on morphology and relative abundances of several forms, especially those from Hebron Fjord (58°10′N). The fishes of Labrador, including those collected by previous BLUE DOLPHIN expeditions, are discussed by Backus (1951 and MS[2]).

The 1952 and 1954 operations were supported in part by the Office of Naval Research through the Arctic Institute of North America and in part by the U. S. Navy Hydrographic Office. In addition the senior author was supported in part by National Science Foundation Predoctoral Fellowships for 1954–56. The authors' thanks for aid in making the present collections are due Mr. William Z. Lidicker, Jr. of the University of Illinois, biologist on the 1952 expedition; Commander David C. Nutt of Dartmouth College, master; Dr. Per F. Scholander of the University of Oslo, Norway, leader of the shore party on the 1954 expedition; Dr. Levie van Dam of the Philadelphia Academy of Arts and Sciences, physiological chemist on the 1954 expedition, and the members of the crew of the BLUE DOLPHIN during both summers. Peter Hay, a native of Nain, Labrador, gave invaluable aid as guide to the 1954 expedition.

AREAS STUDIED

Between 28 June and 25 August 1952 forty-three collections of fishes were preserved by Mr. Lidicker at numerous points along the Labrador coast between Pigeon Cove, on the west side of Newfoundland Island (53°51′ N, 57° 00′W) and Jerusalem Bight, just north of Hebron (58°14′N, 62°38′W). The fishes from these collections discussed in the following account are those providing noteworthy new information.

The senior author's fish collections in 1954 were concentrated in central Hebron Fjord just off the expedition's base camp on the south shore (58°06′N, 62°59′W). Nine collections of bottom fishes were made with a fifteen foot otter trawl between 9 and 31 July. Water depths were in the range 110–125 meters. Temperatures below 100 meters were very near −1.7°C throughout. Salinity below 100 meters was very near 32.6 0/00. A single additional collection in the fjord was made in 220–250 meters about seven miles east of the camp (approximately 58°10′N, 62°50′W), off Winnie Bay, on 18 July. Temperature and salinity conditions in the bottom waters in the latter area were the same as for the camp area. The bottom in both areas was gray to brown mud, with scattered small rocks also present off Winnie Bay.

Commander Nutt and the crew of the BLUE DOLPHIN made additional collections of fishes mostly with a ten foot beam trawl, in the vicinity of Hebron settlement, near the entrance to Hebron Fjord, and at Eastern Harbor, Palliser Island, Saglek Bay (58°33′N, 62°42′W) between 1 and 3 August, 1954.

Fishes preserved during both summers are deposited in the collections of the U. S. National Museum, Washington, D. C., and the Museum of Comparative Zoology, Cambridge, Massachusetts.

DISTRIBUTIONAL AND SYSTEMATIC NOTES

Salvelinus fontinalis (Mitchill). Brook trout. —50 specimens, 104–188 mm. in standard length, were caught by hook and line in and off the mouth of the brook flowing into Nutak Harbor north of Nutak village (57°28 N, 61°50′W) on 29 July and 6 and 7 August 1952. Heretofore this species had been collected north only to Nain (56°35 N). Although it is largely replaced in coastal streams north of Nain by the arctic charr (*S. alpinus*), it is probable that small populations such as the one reported here are more or less continuously distributed around Cape Chidley into Ungava Bay, where Dunbar and Hildebrand (1952) report it common in the George River.

[1] Contribution No. 800 from the Woods Hole Oceanographic Institution.

[2] This and subsequent citations of Backus (ms) refer to an unpublished Ph.D. thesis submitted to Cornell University in 1953.

Pholis fasciatus (Bloch and Schneider).—1 specimen, 171 mm., beam trawl, 4–15 fm., channel E of Semekutak I. (57°33 N, 61°44′W), on 29 July 1952; 2 specimens, 170 and 211 mm., beam trawl, 3–4 fm., Nutak Hbr., 4 August 1952; 3 specimens, 121–135 mm., 10 foot seine, surface to 2.5 feet, Nutak Hbr., 6 August 1952; and 1 specimen, 215 mm., beam trawl, 6–10 fm. rocky bottom, Eastern Hbr., Palliser I., Saglek Bay, 2 August 1954. Heretofore only 2 Labrador specimens had been collected. This species is not found in tide pools where its congener, *P. gunnellus*, is so abundant but occurs below low tide level. Dorsal fin spines vary as follows (in same order as listing above): 87; 89, 89; 88, 88, 88; 89.

Pholis gunnellus (Linnaeus). Gunnel.—10 specimens, 70–240 mm., 10 foot seine, surface to 2.5 feet, Nutak Harbor, 6 August 1952. Heretofore the gunnel had been found north to West Turnavik Island (55°15′N). This species is unknown from Hudson and Ungava Bays, so the Nutak record is the northernmost on the American shore. The dorsal fin ray count was as high as 85 in this collection. Since we have counted as few as 84 rays in Labrador *P. fasciatus*, the clean separation between the two species found by Jensen (1942) in Greenland does not exist here.

Two males, 227 mm. and 226 mm., with swollen testes have an extension of the margin of the dorsal fin membrane which extends posteriorly for about 40 fin rays in the larger specimen and about 20 fin rays in the smaller. This extension is scalloped, the indentations between the thickened membranous tabs corresponding to the position of the fin rays. The extension is orange with a dusky margin. Six males 186 to 240 mm. with unswollen testes lack this extension.

Lumpenus lumpretaeformis (Walbaum). Snake blenny.—1 specimen, 121 mm., from codfish stomach, channel E of Semekutak I., 29 July 1952. Fin ray counts are D74, A49. Excepting Dunbar's (1947) report of two planktonic post-larvae from Hebron this is the most northerly record from our coast. We follow Bigelow and Schroeder (1953) in the spelling of the trivial name.

Lumpenus fabricii Reinhardt.—1 specimen, 230 mm., beam trawl on rocky bottom, 6–10 fathoms, Eastern Harbor, Palliser Island, Saglek Bay, 2 August 1954. Fin ray counts are D62, A43; no palatine teeth. This is the first record for this species from Labrador. Vladykov (1933) and Dunbar and Hildebrand (1952) have shown this species to be quite widely distributed in Hudson and Ungava bays, respectively. It is also of regular occurrence in west Greenland (Jensen 1944).

The closely related form, *Lumpenus medius* Reinhardt, is widely distributed in Labrador (Backus 1951 and MS) and east and west Greenland (Jensen 1944). It has not been recorded, however, from Hudson or Ungava Bays.

Lycodes pallidus Collett—5 specimens, 115 to 222 mm., Hebron Fjord: 2 from area off camp, 3 from deeper water off Winnie Bay, 11–18 July 1954. This is the second collection of this form from Labrador, bringing to 8 the total of specimens known from this area—all from Hebron Fjord (see Backus MS).

Myoxocephalus quadricornis (Linnaeus)—6 specimens: 5, 17–22 mm., 1, 82 mm., seine head of Jerusalem Bight, 19 July 1952. The second collection from Labrador. Previously known only from Nain (Backus MS). This species is also scarce in Ungava Bay (Dunbar and Hildebrand 1952), where *M. scorpius*, again as in Labrador, is common. Vladykov (1933) records both *M. quadricornis* and *M. scorpius* as being widespread and common in Hudson Bay.

Myoxocephalus scorpioides (Fabricius)—1 specimen, 46 mm., seined at the head of Jerusalem Bight, 19 July 1952. Only 7 Labrador specimens are known of this species which is common in Ungava and Hudson Bays.

Triglops nybelini Jensen—1 specimen, a male, 105 mm., area off Hebron Fjord camp, 24 July 1954. The second record from Labrador.

Cyclopterus lumpus Linnaeus—18 specimens, 18 to 31 mm., in shallows in Nutak Harbor, many found clinging to kelp, 6 to 9 August 1952. This is the most northerly locality for Labrador, though as pointed out by Backus (MS), the species probably occurs all along the coast.

Liparis atlanticus (Jordan and Evermann)—2 specimens, 35 and 36 mm., beam trawl in 4–8 fathoms, on hard sandy mud bottom, Hebron Harbor, 18 July 1952; 1 specimen, 52 mm., seined along shore at low tide, sand bottom, Nutak Harbor, 6 August 1952. These are the third and fourth collections of this fish from Labrador. Dunbar and Hildebrand (1952) record 1 specimen from Ungava Bay taken in

1949, that fish having been the first of the species taken north of the Gulf of St. Lawrence.

Liparis tunicatus (Reinhardt)—1 specimen, 61 mm., beam trawl in 4–5 ½ fathoms on mud bottom, Indian Harbor, Hamilton Inlet (54° 27′N, 57°12′W), 16 August 1952; 1 specimen, 46 mm., beam trawl in 6–10 fathoms on rocky bottom, Eastern Harbor, Palliser Island, Saglek Bay, 2 August 1954. The former locality is the most southerly station for the species on this coast. According to Dunbar and Hildebrand (1952) this form is very abundant in Ungava Bay. It is apparently unrecorded from Hudson Bay.

Liparis cyclostigma Gilbert—31 specimens, 55–192 mm., 15 foot otter trawl, 65 ± fm., mud bottom, Hebron Fjord off 1954 expedition camp, 9–31 July, 1954; 1 specimen, 128 mm. 15 foot otter trawl, 120–135 fm., mud bottom with some rock, Hebron Fjord off Winnie Bay, 18 July 1954.

The inclusion of several large individuals in the present collections enables us to determine that the specimens reported by Backus (ms.) as *Liparis sp.* belong here. In the new material the distance from the posterior margin of the disc to the origin of the anal fin varies from 14 to 21 per cent of the standard length. In the single large Labrador specimen heretofore known this distance constituted 12 per cent. According to Gilbert and Burke (1912) this distance constitutes 20 per cent in *L. cyclostigma.*

Color notes on large, fresh specimens in the present collections describe the species as having a background of pale reddish-pink with brassy-yellow overtones; the chin and disc white; upper parts of head and sides vermiculated with greenish brown, melanophores fairly dense on upper head; edges of pectorals dark with green tone; vertical fins alternately banded with light and blackish areas. This agrees well with the description of *L. cyclostigma* given by Gilbert (1895).

Fin ray counts for fifteen specimens are as follows: Dorsal fin: 40 rays—2 specimens; 41–1; 42–4; 43–5; 44–3. Anal fin: 32 rays—2 specimens; 33–2; 34–5; 35–4; 36–2.

This species, described from the Bering Sea by Gilbert (1895) and reported by Vladykov (1933) from Hudson Bay, thus appears to have an arctic American distribution. The fact that it lives in the very cold water suggests that it may prove to be circumpolar when the systematics of this genus are better known.

Reinhardtius hippoglossoides (Walbaum)—2 specimens, 83 and 107 mm., 15 foot otter trawl in 110–125 meters on mud bottom, off 1954 expedition camp, Hebron Fjord, 11 July 1954. This is the first record of this species for Labrador. Dunbar and Hildebrand (1952) record the first captures of this form from Ungava Bay, in the vicinity of Port Burwell. The species is known in the western North Atlantic from northwest Greenland to a point on the slope off Georges Bank in about longitude 68°W (Schroeder, 1955).

Relative Abundances of Fishes in Hebron Fjord

As described above, nine collections of bottom fishes were made between 9 and 31 July 1954 in the 110–125 meters in the portion of Hebron Fjord adjacent to the expedition base camp. For five of these collections, involving seven 20–30 minute hauls with the 15 foot otter trawl between 9 and 15 July, careful notes were kept on the exact numbers of each species of fish captured; hence we can estimate their relative abundances. That larger and more active individuals of some of the species may have eluded our small net, though it was towed fairly rapidly, is recognized as a source of error. The majority of the forms, however, are small and fairly sluggish.

The following table lists the species in these five collections, with the numbers of each captured:

Species	No. captured
1. *Icelus spatula*	69
2. *Boreogadus saida*	45
3. *Lycodes turneri turneri*	42
4. *Liparis cyclostigma*	17
5. *Liparis koefoedi*	10
6. *Gymnacanthus tricuspis*	5
7. *Lumpenus medius*	2
8. *Lycodes reticulatus*	2
9. *Lycodes pallidus*	2
10. *Reinhardtius hippoglossoides*	2
11. *Leptoclinus maculatus*	1
12. *Triglops pingeli*	1
13. *Eumicrotremus spinosus*	1

One or two individuals of three additional species were captured during the course of later operations in the same area: *Triglops nybelini*, *Agonus decagonus*, *Aspidophoroides olriki*. None of the otter trawl collections made in the deep waters of the interior of Hebron Fjord by earlier BLUE DOLPHIN expeditions contain any additional species. The relative abundances of the various species are very similar in these other collections to those listed here.

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Lanthanotus and the Anguinomorphan Lizards: A Critical Review

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THE recent work of McDowell and Bogert (1954) on "The systematic position of *Lanthanotus* and the affinities of the anguinomorphan lizards" represents a notable contribution to Squamatan morphology and systematics. The skulls of the problematic forms *Lanthanotus* and *Shinisaurus* are described for the first time. Darlington (1948) comments on the rarity of these two forms and adds "Whoever can obtain sufficient material to compare the skeletons of these lizards and determine their relationships will make a real contribution to zoogeography." Some new data and figures are also presented for *Heloderma*, geckos, Pygopodidae, Cordylidae and Anguinidae. They discuss the systematic position of *Lanthanotus*, *Shinisaurus*, *Heloderma*, Pygopodidae, Cordylidae, Leptotyphlopidae and Typhlopidae, the affinities of snakes and the evolution and systematics of Anguinomorphan lizards. Some important data are presented and some valuable systematic proposals are made. I have therefore been distressed to find a number of errors and very dubious morphological interpretations in the descriptive sections and some firmly expressed opinions which rest upon an inadequate and unbalanced consideration of the evidence. I therefore essay a critical discussion of this work. The need for criticism is underlined by the fact that a reviewer has characterised the work, without qualification, as a "... competent report..." "which... will be of great value in elucidating the problem of the origin of snakes" (Grobman, 1955). Bogert himself has apparently had second thoughts on some of the work for Bogert and Martin del Campo (1956:209) state "... McDowell and Bogert (1954) have managed to obfuscate the relationships of virtually all the Squamata". This is unduly harsh, I would put the fraction at about half of the Squamata. The distasteful task of destructive criticism is, I believe, necessary for the preservation of the valuable parts of the work. My comments are largely documented by reference to published works, most of which are cited by McDowell and Bogert (these latter are marked by an as-

terisk). The detailed checking of such sections as I was able involved reference to a number of specimens, a few new personal observations are therefore included.

The authors are to be complimented for their examination of the scale-organs of the lizards which they studied. These organs, widely distributed in lizards and snakes, have been largely neglected by systematists, with the exception of those on the trunk of Colubrid snakes.

The orbital cartilages were apparently removed in preparation of the skull of *Lanthanotus* and the orbitosphenoid, if present, presumably went with them for it is not mentioned in the account of the braincase (p. 13). It is stated that the orbits of *Lanthanotus* are separated by the descending laminae of the frontals (p. 19). It is stated later (p. 37) that there is a double interorbital septum, a highly improbable condition. Bellairs' study (1949b) makes it clear that the presence or absence of an interorbital septum is determined by the relationship of the braincase (here largely formed by the frontals) to the trabeculae. He showed, for example, that a low interorbital septum can be seen in transverse sections of the head of *Anniella*, a form in which it had been believed to be absent.

The statement that the stapes runs from the "fenestra ovalis to the quadrate" (p. 12) seems to imply that it meets the quadrate. Inspection of the photograph (Pl. 3, Fig. 1) shows that the stapes cast a shadow on the quadrate thus indicating that there is a gap between them.

Lanthanotus is compared with *Shinisaurus*. Through the courtesy of the authors I received an eye of *Shinisaurus* which was, as they noted, poorly preserved. The lower eyelid contains a cartilaginous tarsus, a common feature in large lizards, not likely to be present in *Lanthanotus* which has a window. The pupil is round with a tiny notch on the ventral margin indicating the position of the chorioid fissure. There is the usual complement of 14 scleral ossicles maintaining a pronounced scleral sulcus. The anterior and posterior margins of the scleral ossicles overlap. Most of the ossicles have a somewhat irregular "waist" so that there are gaps between them, this again is very much as in a number of large lizards. The lens shows the proportions found in diurnal lizards, it is fairly flat. There is a large pigmented conus of triradiate cross-section. The preservation did not admit of checking the presence or absence of fovea. The lens fibres are arranged in 225 radii meeting in a central point. There is nothing in the above points to suggest that the eye does not belong to a large diurnal lizard, although this does not necessarily prove diurnal habits. It is to be noted that Barrows and Smith (1947) found about 20 scleral ossicles in *Xenosaurus*. This undoubtedly represents a secondary increase.

McDowell and Bogert compare the external appearances of *Lanthanotus* and *Shinisaurus* and note a good measure of difference. The skull of *Shinisaurus* was prepared and is described and figured. The palpebral bone is shown in such a position that I find it difficult to believe that it did not block the animal's vision. Many differences between the skulls of *Lanthanotus* and *Shinisaurus* are described. A tiny bone is described and figured (p. 20) exposed on the posterior face of the skull in contact with parietal, tabular and paroccipital process. In the text no suggestion is made concerning its identity. In the figure it is labelled as a "probable stylohal bone". Later (p. 27) it is compared with similar elements found in *Melanosaurus* by Gilmore (1928), an Eocene fossil and in *Xenosaurus* by Barrows and Smith (1947).

I can see no grounds for regarding it as a stylohyal, an element derived from the dorsal part of the hyoid arch of crocodiles, birds and mammals (deBeer, 1937) and in any case an element which does not ossify.

The relationships of the vomers are discussed (p. 20) in the two genera. Unfortunately no attempt is made to consider the matter in the light of Bellairs's and Boyd's work on the palate and lacrimal duct (1947). Noteworthy in *Shinisaurus* is the wide separation of the vomer from the maxilla over the greater part of its length with however a small transverse spur behind the opening of Jacobson's organ (which meets the maxilla as in *Xenosaurus*?). The photograph (Pl. 6, Fig. 2) of the palate of *Shinisaurus* purports to show the "palaeochoanate" form of the entrance to the organ of Jacobson. This terminology applies to the condition of the palate in any case. The photograph is rather small but there appears to be an open groove connecting the internal choana with the duct of Jacobson's organ, the choanal fold does not seem to be wide enough to meet the lateral margin of the vomer. The transverse spur of the vomer must

however separate the fenestra vomeronasalis from the fenestra exochoanalis so that the palate cannot be described as "palaeochoanate". The only anguinomorphs described by Bellairs and Boyd were *Celestus*, *Anguis*, *Anniella* and *Varanus*. *Shinisaurus* and *Xenosaurus* evidently diverge widely from these (and other lizards investigated); it would be worthwhile to check the condition of *Xenosaurus*.

The account of the foramina in the occipital region of the skull is confused. Valuable references are Bahl's (1937) excellent account of the skull of *Varanus monitor* in which he pays special attention to the foramina, and Versluys's (1898) careful study of the middle ear in a number of different lizards in which he describes the course of blood vessels and nerves. Leaving the occipital region of the skull are the glossopharyngeal (IX), vagus (X), spinal accessory (XI) and hypoglossal (XII) nerves and the vena cerebralis posterior branch of the internal jugular vein. Entering the skull is the occipital branch of the occipito-vertebral artery (Bahl). In reptiles the recessus scala tympani is a chamber in the skull wall (exoccipital) below and in communication with the labyrinth of the inner ear. Through this chamber the ductus perilymphaticus passes from the inner ear to the braincase. In birds, crocodiles and some chelonia the internal jugular vein enters the skull through the recessus scala tympani. Amphisbaenians are the only lizards in which the internal jugular vein is known to persist in the adult. In *Sphenodon*, other lizards and snakes this vein is present in the embryo but later disappears; the recessus scala tympani is largely filled by the saccus perilymphaticus. The external opening is known as the fenestra rotunda or external jugular foramen, it is closed by the membrana tympani secundaria. The glossopharyngeal nerve leaves the skull by the recessus scala tympani (*Sphenodon* and amphisbaenians excepted) emerging through the fenestra rotunda (Versluys). It is clear that McDowell and Bogert mean this foramen when they refer to the "jugular foramen on [the] lateral surface" of the exoccipital (p. 22) of *Shinisaurus* and the "lateral aperture" of *Lanthanotus* and *Varanus* (p. 50) and *Heloderma* (p. 41). The statement that the "lateral aperture" is, in *Varanus* and *Heloderma*, for the jugular vein is true only for the embryonic condition which they do not purport to discuss (Versluys examined *Varanus monitor*, *V. salvator* and *Heloderma suspectum*).

On the posterior face of the exoccipital the vagus nerve and vena cerebralis posterior vein leave and the occipital artery enters by a large foramen. The spinal accessory and hypoglossal nerves commonly leave by small separate foramina. In *Varanus* the internal openings of these foramina lie behind the internal opening of the vagus foramen (=jugular foramen of Bahl), the spinal accessory foramen dorsal, the hypoglossal foramen ventral. These two foramina are externally confluent with the vagus so that the three nerves leave the skull together (Bahl). This is evidently the basis for the incorrect statements that *Varanus* has the "vagus passing through the hypoglossal foramen" (p. 22; p. 55; p. 131; Fig. 43 legend above "Platynota"). I suggest that it is not true of *Lanthanotus* (as suggested p. 22). With regard to *Heloderma* we read that the "lateral aperture" is for the "glossopharyngeal, vagal, and accessory nerves" (p. 41), this is very doubtful.

After defining the jugular foramen of *Shinisaurus* as lying on the "lateral surface" (p. 22), i.e. as foramen rotundum, they state that "in *Shinisaurus* the vagus makes its normal exit from the jugular foramen". This would certainly be a monstrous exit unless in the one paragraph they use the term "jugular foramen" in two senses (that of Versluys and that of Bahl).

The hyobranchial apparatus of *Lanthanotus* is compared with that of *Shinisaurus* (p. 24) and later with that of *Heloderma* (p. 43) and *Varanus* (p. 51). It is difficult to make out what information the authors intend to convey because they reverse the names of the parts. The median glossohyal (basihyal of Camp) bears a forwardly directed lingual process. From the posterior transverse expansion the lower limb of the hyoid arch runs forwards, this is "ceratohyal" on pp. 24 and 51 and "hypohyal" on p. 43. This limb turns outwards and backwards continuing as an upper limb (ceratohyal of Camp), this is "hypohyal" on p. 24 and 51 and "ceratohyal" on p. 43.

The general conclusion that there is no special affinity between *Lanthanotus* and *Shinisaurus* is, I believe, sound; as also that the affinities of *Shinisaurus* lie with the Diploglossa. The case

for special affinity between *Shinisaurus* and *Xenosaurus* is convincing, a number of points of mutual difference from the Anguinidae are listed. The statement that scale-organs are not found on any Anguinid (p. 26) does not agree with my own observations. In several Jamaican species of *Celestus* I find these organs on the head scales and trunk scales, and in *Anguis fragilis* on the head scales.

Several fossil genera are discussed on the basis of published descriptions and referred to the Xenosauridae.

The authors then compare *Lanthanotus* with *Heloderma*, the genus to which it has generally been supposed to be related. There appears to be some confusion of the morphology of the parasphenoid and trabeculae (p. 37; p. 50) although they are correctly distinguished elsewhere (p. 40). The trabecular cartilages are paired in the early embryo. In lizards they unite at midorbital level to form the trabecula communis. The parasphenoid is a dermal bone which fuses with the basisphenoid. If it develop a cultriform process it lies ventral to the trabecula communis: there is no "cartilage of the cultriform process" (deBeer 1937, Bellairs 1949b). They conclude that *Lanthanotus* shows no special resemblance to *Heloderma* beyond general Platynotan features and a few convergent characters.

In the comparison of *Lanthanotus* with *Varanus* its true close affinities emerge clearly.

One of the more striking resemblances lies in the possession of two lacrimal foramina. In both the upper foramen lies between lacrimal and prefrontal bone, in *Varanus* the lower foramen lies within the lacrimal, in *Lanthanotus* it lies between lacrimal and prefrontal. As is well described and figured by Bellairs for *Varanus* (1949a) there are two separate lacrimal ducts, the upper opening anteriorly into the duct of Jacobson's organ, the lower opening into the nasal passage. This matter is unfortunately not discussed. The more primitive condition of the palate of *Lanthanotus* suggests that it may give us some idea of how the peculiar condition of *Varanus* was evolved.

Bellair's sections through the snout of *Varanus monitor* (1949, Fig. 4) do not bear out the implication that the soft palate of *Varanus* bears a pair of grooves "where the tines of the deeply forked tongue lie" corresponding to the "deep grooves" on the "ventral surface of the vomers" (p. 49).

In *Varanus*, and as far as I know all other lizards (except chamaeleons) and snakes, the Vidian canal (transmitting internal carotid artery and palatine branch of the facial nerve) lies entirely within the basisphenoid. A small foramen admits the cerebral branch of the internal carotid from the Vidian canal into the pituitary fossa (geckos excepted). I therefore doubt that in *Lanthanotus* and *Shinisaurus* "the pro-otic forms the dorsal border for the foramen" leading to the Vidian canal. I further cannot agree that the Vidian canal of *Varanus* is "very short" (p. 50). I do not find it to be short in *Varanus* or a number of different snakes when compared with other lizards.

Having made a strong case for affinity between *Lanthanotus* and *Varanus* the authors then examine the relationship with fossil Platynotans. They find some special resemblances with the Aigialosauridae, and suggest that the "precise affinities" of *Lanthanotus* are with "the aigialosaur-dolichosaur-mosasaur complex, rather than with the varanids or *Heloderma*."

Following these descriptive sections are several discussions. First they discuss the case for platynotan affinity of snakes. It is my opinion, which many do not share, that the case for platynotan affinities of snakes is not yet sufficiently well established. Unreserved acceptance of this case obscures the need for further active search for evidence bearing on the affinities of snakes. Some of the evidence cited by the authors "bearing on the origin of snakes from a monitorlike lizard" is of doubtful value. I review their twelve points in sequence.

1. To the list of non-platynotan lizards which are without caudal autotomy septa may be added *Dibamus*. In any case loss of the autotomy septa is surely a minor change. In *Cyclura* I find that whereas breakage and regeneration of the tail make take place in the juvenile, the two halves of each caudal centrum are solidly co-ossified in the adult, often without trace of suture.

2. The "row of papillae along the lateral margin of the protrusible portion of the tongue" of many snakes does not recall the "tongue structure of *Lanthanotus*" as it is described on p. 10. A protrusible tongue has been independently evolved in the Tejidae.

3. A resemblance between ophidian and platynotan vertebrae is clear from the account. I was interested to find that the trunk vertebrae of the iguana *Cyclura carinata* agree even more closely with snake vertebrae. The centrum is constricted posteriorly, the condyle is obliquely pointed dorsally, there are subcentral foramina and there are zygosphenes and zygantra. The resemblances between these three stocks are surely more likely to be due to adaptive factors than to phyletic affinity.

4. It does not seem right to refer to the caudal haemapophyses of snakes as chevrons. They are paired processes of the centra (in bony continuity therewith) and they do not unite to form chevrons. Failure of union of the two halves does not, I believe, occur in the Platynota but is found in *Anniella* (Camp).

5. I feel that the case for ophidian-platynotan affinities deduced from tooth structure is overstated. The "recurved and acute form of the crown" is a fairly simple feature of such obvious adaptive significance that it cannot carry much weight. I do not see a "finely fluted base" to the teeth of several different snakes to hand (*Python molurus*, several colubrids). That the teeth of snakes are normally replaced alternately does not seem to me to exclude successional replacement at any one locus. The figure (fig. 30) given to show the difference between the tooth replacement of non-anguinomorphan and anguinomorphan lizards illustrates a genuine difference; it seems to me to be a difference between perpendicular succession and oblique succession. The anguinomorph tooth does not appear, as in snakes, to move into the gap between two old teeth.

6. If we consider those snakes which retain the primitive attachment of premaxilla to maxilla (Xenopeltidae, Uropeltidae) the agreement between Platynota and snakes disappears. In snakes in which the rostral bones are movable there are obvious adaptive reasons for interruption of close nasal-prefrontal contact.

7. The pattern of dorsal median cranial sutures is a weak character at the best of times, as recognised by Camp. I do not believe that fusion of nasals is as common in snakes as the authors suggest. Bellairs (1949a) figures paired nasals in transverse sections of the snout of *Xenopeltis*. I find that the nasals are separable in several colubrids and in *Epicrates subflavus*.

8. I see no good grounds for the suggestion that there is a special resemblance between snakes and Platynota in respect of the manner of enclosure of the forebrain by the frontals. The authors do not make a distinction between enclosure of the forebrain by the frontals, which occurs in a number of unrelated stocks of diverse habits, and reduction of the interorbital septum, which occurs in association with reduction of the eyes. Where the interorbital septum is lost the frontals rest on the trabecula communis (Amphisbaenidae) or the parasphenoid and paired trabeculae (snakes). The Platynota make no special approach to the condition of snakes, the braincase is wide-open anteriorly and in *Varanus* there is a well developed set of orbital cartilages and a high interorbital septum (Bellairs, 1949b). The Gekkota and *Anniella* are dismissed as having "much less well developed descending processes." If the descending processes meet beneath the forebrain (all Gekkota) and be solidly co-ossified (many Gekkota) how much better can they be developed? The orbital cartilages of the Gekkota further show reduction, which may be considerable approaching the snake condition.

9. It is stated that snakes of the "primitive genus *Sibynophis* retain a double [lacrimal] foramen very similar to that of Platynota". The fact that Platynota have quite a large lacrimal bone and snakes have none must surely preclude the possibility that the lacrimal foramina could be "very similar". Nowhere is the significance of the double lacrimal foramen discussed although it is fully described by Bellairs (1949a) and Bellairs and Boyd (1947) for *Varanus*. Bellairs and Boyd studied representatives of all families of snakes except the Leptotyphlopidae. They found in all a single lacrimal duct passing through a single foramen in the prefrontal. The claim that snakes of the genus *Sibynophis* have two lacrimal foramina requires more evidence that the observation of two holes in the bones on the anterior side of the orbit. If the claim could be substantiated it could constitute the most convincing piece of evidence in the list.

10. As pointed out above the "shortened entocarotid canal" seems to be an imaginary character.

11. The "aigialosaurian" hinge in the lower jaw merits careful consideration. The systematic position of the snakes in which it is stated that there is a movable articulation suggests

that it may be a primitive feature. On the mesial face the hinge is mainly between coronoid and angular proximally and the splenial distally. On the lateral face the surangular overlaps the dentary. In the Platynota the straight suture is on the lateral face between the dentary distally and, mainly, surangular proximally. Mesially there is overlapping of bones in *Varanus* but in *Lanthanotus* and mosasaurs there is a more or less straight contact between dentary and splenial distally and coronoid, prearticular and angular proximally. The resemblance is thus fairly detailed. There is on the other hand only one level at which a Squamatan lower jaw could easily develop a hinge. It is further a character of clear functional significance in animals which swallow relatively large vertebrates. I had a *Varanus monitor* of trunk length 275 mm. which regularly ate male *Calotes versicolor* of trunk length 100 mm. without mechanical crushing; these latter have quite large heads. This is a matter on which more evidence can be collected. Camp mentions that the throat muscles of *Varanus* are complicated in association with the presence of the hinge in the lower jaw. If the resemblance between the ophidian and platynotan hinge be due to phyletic affinity we might reasonably expect it to extend to the associated muscles.

12. It is difficult to know what to make of the claim that snakes and Platynota resemble one another in the "lack of lateral exposure of the angular". In the figures of McDowell and Bogert the angular is clearly shown in lateral view in *Lanthanotus*, *Heloderma*, *Varanus*, *Aigialosaurus*, *Opetiosaurus* and *Tylosaurus* although the Platynota are said to differ "in this respect from the anguinoids" of which latter *Shinisaurus*, *Xenosaurus*, *Diploglossus*, *Gerrhonotus*, *Melanosaurus*, *Peltosaurus*, *Anguis* and *Anniella* are figured as showing the angular in lateral view. The angular is not distinct in lateral view in the figure of *Python argus*.

After arriving at the conclusion that snakes have originated from some kind of platynotan lizard the authors discuss the question of particular affinity with known platynotan stocks. Their case that *Lanthanotus* makes a closer approach to the snake condition than any other platynotan rests upon the assumption of platynotan-ophidian affinities.

Lanthanotus is stated to possess pterygoid and palatine teeth. Pterygoid teeth are visible in the figure (Fig. 2) and photograph (Pl. 3). In the figure two palatine teeth are shown on the left and one on the right; in the photograph faint indications of teeth are visible on the left but no indications are visible on the right. It is stated that boid and many colubrid snakes have papillae on the lateral margin of the posterior portion of the protrusible fore-tongue. Although it is argued that *Lanthanotus* bears a special resemblance to snakes in respect of tongue structure neither text nor figure (Fig. 29e) suggest that the foretongue of *Lanthanotus* bears any papillae.

In arguing a special resemblance between the vomer of *Lanthanotus* and that of snakes (p. 64) the authors overlook one of the distinctive features of the ophidian vomer; there is a close sutural union of vomer and septomaxilla forming a capsule in which is enclosed the organ of Jacobson. They point out that the vomer is generally associated with a complex of rostral bones which articulate with the frontals. They claim that "in most snakes. . . the vomer is its chief or only means of attachment to the remainder of the skull, the vomerofrontal contact being modified to form a ginglymous joint". If we accept the case that the contact between vomer and frontal of *Lanthanotus* constitutes evidence for snake affinities then we should expect to find such a contact in those snakes which retain the primitive premaxillary-maxillary contact. Bellairs's figures (1949a) make it quite clear that there is a wide gap between vomer and frontal in *Xenopeltis*; the same also appears to be true of *Rhinophis* (1949b).

A vomer-frontal contact is figured for *Python argus*. A skull of *Python molurus* to hand shows a wide gap between vomer and frontal (about 10% of head length), the rostral complex is attached by a nasal-frontal articulation[1]. In four colubrid skulls to hand I find no vomer-frontal contact (*Atretium schistosum*, *Dromicus callilaemus*, *Ptyas mucosus*, *Dryophis nasutus*). The ventral margins of the apposed median flanges of the nasals meet the frontals in an articulation and the septomaxillae extend caudal to the vomers and articulate with a pair of

[1] Several correspondents have suggested that my account of the vomer-frontal relationship of *Python molurus* is incorrect. The skull was prepared by masceration from a "no data" museum specimen labelled "*Python molurus*". The length from premaxilla to occipital condyle is 7.0 cm.; there is a ligamentous nasal-frontal contact and a 7 mm. vomer-frontal gap. There is nothing to suggest that the vomers have been broken. Perhaps the identification is incorrect, *molurus* differs from other species or the specimen is abnormal.

medio-ventral facets on the frontals. This has been confirmed by examination of serial sections through the head of *Dromicus callilaemus*. The caudal processes of nasals and septomaxillae are tied together in a bundle no doubt thus gaining rigidity. The septomaxillae and frontals articulate by expanded facets. These were evidently mistaken for vomero-frontal contacts by McDowell and Bogert. Comment has already been made on the weakness of the discussion of the relations of frontals to forebrain and orbits.

After discussing several fossil snakes on the basis of published descriptions the authors review the status of the Leptotyphlopidae. It is claimed that the foramen for the optic nerve in the frontal constitutes a distinctive feature of the family. This is however also the case in *Typhlops* (Haas, 1930; Smit, 1949) and *Rhinophis* (Bellairs 1949b). The general conclusion that the Leptotyphlopidae represent divergent descendants of ancestral snakes is, I think, quite reasonable.

There follows a discussion of the status of the Typhlopidae. A number of anatomical features of the family are reviewed. An interpretation of the circumorbital bones is then offered in a manner which reduces morphology from a branch of biological science to the status of a jig-saw puzzle. Most snakes have only two circumorbital bones, the prefrontal and a bone which may be postfrontal or postorbital. Pythons have a third bone between these; it is usually non-committally termed a "supraorbital" but it is by some quite reasonably regarded as a postfrontal. *Anomalepis* and *Liotyphlops* have three circumorbital bones; a clearly recognisable prefrontal, a bone above the orbit lateral to the frontal and a bone behind the orbit. McDowell and Bogert give a merely geometrical interpretation by comparing the pattern of bones with that of an anguinid lizard, *Celestus costatus*, from which a portion of the maxilla has been cut away to improve the geometrical resemblance! The fact that *Celestus* has firm upper jaws and a metakinetic skull and that the typhlopids have extremely mobile maxilla and limited mesokinesis of the skull are not considered. The geometrical relationships of bones to eyes are discussed without taking any account of the great difference in relative eye size.

There is a laboured interpretation of the morphology of the frontals of *Typhlops* (p. 80). It is assumed that a morphologically valuable distinction may be made between "dorsal plate" and "descending lamina" of the frontal although in *Typhlops* the "frontal bone itself shows no sharp angulation". The supraorbital process of the prefrontal is used to define the boundary between these two parts of the frontal. As this process is simply applied to the outside of the frontal its value for defining a morphologically meaningful boundary is doubtful and is in any case later negated by the statement (p. 82 and 83) that "the prefrontal has retreated inward away from the maxilla". The descending processes of the frontals are described as small but it is not explained how they could be larger when they already descend to the floor of the braincase and meet one another.

The passing suggestion that the presence of the lacrimal is "largely dependent on the presence of movable eyelids" does not tally with its absence from chamoeleons and many agamids in addition to the families mentioned (p. 80).

The comparison of the braincase of *Typhlops* and amphisbaenids (p. 81) rests on confused nomenclature, erroneous morphology and unfair misrepresentation of the findings of Zangerl (1944). It also overlooks the full and clear explanation of these matters given by Bellairs (1949b). The laterosphenoid (= pleurosphenoid) is an ossification of the pila antotica behind the oculomotor nerve (III) and before the trigeminal ganglion (V). The orbitosphenoid (= postoptic of Cope) is an ossification of the pila metoptica behind the optic nerve (II) and before the oculomotor. Nevertheless we see postoptic equated with laterosphenoid at several points (p. 81, twice). In the legend to figure 27 it is stated (of *Gerrhonotus albigularis*) "laterosphenoid or post-optic included, but omitted from all other drawings...". This falsely equates two different bones and conveys the erroneous impression that postoptics were present in all the other skulls figured. The orbitosphenoids described by Zangerl in the amphisbaenid skull are called "laterosphenoids" and the fact that Zangerl described genuine laterosphenoids is ignored (although Bellairs confirmed Zangerl's interpretation). The suggestion that bones anterior to the basisphenoid of *Typhlops* are laterosphenoids is impossible; the suggestion that laterosphenoids might be fused to the septomaxillae is preposterous.

The braincase of *Typhlops* agrees with that of snakes in that: the frontals surround and meet beneath the forebrain enclosing the optic and ophthalmic nerves in foramina which may be conjoined (*T. delalandi*, Smit 1948) or separate (*T. punctatus*, Haas 1930). There is no interorbital septum. The parietals descend around the brain enclosing the ophthalmic nerve. The trigeminal nerve root is enclosed by the prootic.

The argument (p. 84b) that the zygosphenozygantral joints of *Typhlops* are not homologous with those of snakes rests upon the geometrical consideration that these joints are level with the zygapophysial joints. The resemblance to leptotyphlopid vertebrae (including the absence of neural spines) is overlooked.

Although I think that the discussion is badly presented I agree that the Typhlopidae have not descended from any known snake stock. I likewise agree that the Typhlopidae are not close to the ancestry of snakes. The authors then consider a third hypothesis that "typhlopids on the one hand, the snakes and leptotyphlopids on the other, have diverged from each other at an early date but are derived from a common ancestor". They purport to "examine the characteristics considered diagnostic of the Ophidia (including Typhlopidae) and assay their value" (p. 87). Reference may be made to the account of snake features given by Bellairs & Underwood (1951). I also dissected specimens of *Typhlops jamaicensis* and was immediately able to gather further evidence. In reviewing the "examination" I follow their paragraph numbering.

1. The discussion of the braincase rest upon the errors and confusions already pointed out.

2. In discussing the anterior braincase of *Typhlops* Bellairs (1949b, p. 502) states "In the Typhlopidae (Fig. 1E [should be 1D]: Haas 1930) this telescoping of the front of the head has been associated with extreme reduction of the eyes, so that a section through the middle of the orbits passes through the trabecula communis and not through the paired trabeculae as in other snakes". Later, in discussing the possible origin of snakes from a burrowing ancestor Bellairs states (p. 507) "Once a condition like that in *Typhlops* had been reached where the interorbital septum had been reduced to a trabecula communis, a slight increase in eye size unaccompanied by any change in the level of trabecular fusion would result in the typical ophidian state where the chondrocranium is platytrabic at midorbital level. This condition is present in *Rhinophis* (Fig. 9G-J), a form only slightly less adapted to burrowing life than *Typhlops*." Without the addition of a shred of fresh evidence one statement of Bellairs is lifted from its context and used to refute Bellair's carefully presented view that *Typhlops* shows a "modified platytrabic" skull.

Five more features characteristic of snakes are mentioned including the zygospheno-zygantral joints already discussed. Seven features are then mentioned as "indicating derivation of both snakes and typhlopids from anguinomorph ancestors". Contrary to the implication of para. 5 reduction of the extracolumellar apparatus is not an anguinomorph characteristic. *Varanus* has about as elaborate a set of extracolumellar processes as any lizard; *Heloderma*, *Anguis*, *Ophisaurus* and *Xenosaurus* show differing points of reduction but all, as compared with lizards generally, have the extrastapes quite well developed (Versluys, 1898; Barrows and Smith, 1947).

Ventral exposure of the gall-bladder by the liver does not appear to be a general anguinomorph feature (pers. obs. on *Celestus crusculus* and *Anguis fragilis*).

A large number of snake features are completely ignored, including many points in which *Typhlops* is snake-like.

Enclosure of the ophthalmic nerve of *Typhlops* by parietal downgrowths has already been mentioned as also that the optic and ophthalmic nerves pass through foramina in the frontal (in most snakes they emerge between frontal and parietal).

Typhlops possesses the anterodorsally directed processes of the ribs characteristic of snakes.

Typhlops possesses deeply forked lymphapophyses in the cloacal region; the anterior lymphapophyses are movably attached to the vertebral column, a condition found in no snake-like lizards (Salle, 1880). The stapes articulates with the quadrate as in snakes (Evans, 1955).

Harder's gland opens directly into the lacrimal duct in snakes (elsewhere only in pygopods). *Typhlops* agrees with snakes (Bellairs and Boyd, 1950). *Typhlops* also shows a condition of the anterior lacrimal duct and palate similar to the distinctive condition of snakes (Bellairs and Boyd, 1950).

In points of eye structure *Typhlops* agrees

with snakes. The sclera has neither cartilage nor ossicles (absent in no known lizard save *Rhineura*). The visual cells closely resemble those of *Leptotyphlops* (Underwood, 1951); they are small single rod-like cells without paraboloid (present in all known lizards) or oil-droplet (absent only in geckos and pygopods). The eye contrasts sharply with that of all described burrowing lizards (Angel & Rochon-Duvigneaud in Rochon-Duvigneaud 1941).

The facial artery of *Typhlops* passes anterior to the stapes, as in all known snakes; a condition found in no known lizards except pygopods and some geckos (Versluys and pers. obs.).

As in snakes *Typhlops* has no ductus caroticus a feature found also in Platynota (but not Diploglossa) Chamoeleonidae, and Amphisbaenidae (Adams, 1952 & 1953 and pers. obs.) Right and left common carotids are equally well developed as in primitive snakes. There is no dorsal anastomosis between the internal carotids, a primitive feature not known in other snakes (pers. obs.).

In lizards the thymus bodies, derived from visceral pouches II and III, lie well forwards behind the head, even when the bodily form is snake-like (*Varanus*, *Pygopus*, *Anguis*, *Delma*, *Lialis*, *Aprasia*, *Amphisbaena*, *Trogonophis*, Adams & pers. obs.). In snakes the thymus bodies derived from visceral pouches IV & V (Pischinger, 1937) lie immediately in front of the heart (confirmed for Xenopeltidae, Boidae, Colubridae, Viperidae, pers. obs.). In *Typhlops jamaicensis* and *Leptotyphlops humilis* the heart lies well back like that of a snake and the thymus bodies lie immediately in front of it. They are remarkable in that there is only a single pair (pers. obs).

Typhlops and *Leptotyphlops* agree with one another and differ from other Squamata in that the liver is divided into a large number of small lobes.

Snakes differ from all known lizards in that the gall bladder lies well away from the liver, close to the compact pancreas. Hepatic duct and cystic duct unite to form the common bile duct which passes through the pancreas. *Typhlops* agrees well with snakes in this respect. I have been unable to find a spleen in *Typhlops* and *Leptotyphlops*; if its absence be confirmed it will constitute a peculiar feature.

In snakes the abdominal vein receives its blood only from venules from the fat body in contrast to the condition in lizards in which it also receives the two pelvic veins. In *Typhlops* the abdominal vein receives a single "pelvic" vein arising from the right renal portal well forward of the cloaca (pers. obs.).

In lizards, including snake-like forms, the kidneys are quite or very nearly symmetrical. In snakes the right kidney lies forward of the left and both lie well forward into the abdominal cavity. *Typhlops* is entirely snake-like in this respect (pers. obs.).

Cloacal glands producing a strongly odorous secretion are characteristic of snakes; *Typhlops* possesses cloacal glands and their secretion smells like that of a snake (pers. obs.).

Typhlops combines a number of distinctively ophidian features with a few which are clearly primitive from an ophidian standpoint. To these it adds a number of divergent features (a few of them shared with *Leptotyphlops*). In my opinion this argues that the Typhlopidae are divergent descendants of ancestral snake stock. If further study strengthen the case for affinity with the Leptotyphlopidae then I would suggest that the two families have diverged from a common ancestor principally in respect of their adaptations to the swallowing of prey in the restricted space of an underground burrow.

I strongly urge that the Typhlopidae should be retained in the Serpentes. The Typhlopidae and Leptotyphlopidae would well repay further study. Several noteworthy new features mentioned above were revealed by only a few hours work.

In the next section the removal of several families from the Anguinomorpha is discussed. The authors are, I believe, perfectly correct in reviving Boulenger's view that the Pygopodidae are related to the geckos. The show that the so-called "ischia" of pygopods are post-cloacal bones similar to those of geckos (a suggestion hesitantly made by Camp, 1923 p. 330). The frontals of pygopods always meet beneath the forebrain but do not always fuse as stated (*Aprasia*). The jugal bones of geckos and pygopods are not always absent as stated (p. 92), indeed jugals are figured and labelled for *Pygopus*, *Lialis*, *Aprasia*, *Aristelliger*, and *Coleonyx*. Having transferred the Pygopodidae to the Gekkota the authors state that they leave the affinities of *Ophioseps* "an open question". On p. 135 however *Aprasia repens* is listed under the Gekkota in the family Ophiosepidae. This is a completely gratuitous rearrangement.

Jensen (1901) studied *Ophioseps nasutus* and considered it to be related to the Scincidae but sufficiently distinct to merit a separate family, he did not consider the possibility of pygopod affinities. McDowell & Bogert accept Jensen's case for separating *Ophioseps* from the Scincidae as ground for separating it from the Pygopodidae! It would have been surprising if Jensen had not thought a pygopod distinct from the Scincidae.

Some comments are made on the Xantusiidae which it is suggested probably belong to the Gekkota. This might well have been left out of a paper on the Anguinomorpha for the Xantusiidae have been associated with the Scincomorpha. In the text they state that the parietals are separate and the pineal foramen absent; in their figure however I see a distinct pineal foramen and no trace of a parietal suture. The statement that the lacrimal is fused with the prefrontal may be correct but does not appear to rest on any evidence.

There is a well presented case that the Cordylidae are related to the Gerrhosauridae and belong therefore to the Scincomorpha not to the Anguinomorpha. As far as I can make out without material of these families the account is accurate. Although it is stated that in the "Anguinomorpha the postorbital is constantly excluded from the orbit by the juncture of the jugal and post-frontal" (p. 99) some exceptions are later noted (Fig. 38, p. 103).

There is a good discussion of Anguinomorphan phylogeny. Although the name Diploglossinae is used for an anguinid subfamily through the bulk of the paper it appears once as the Celestinae (p. 122).

In the account of *Anniella* the statement that the descending processes of the frontals meet beneath the olfactory tract does not accord with Bellairs's observation (1950) (supported by figures) that the "frontal bones possess downgrowths which are separated by a small gap in the midline ventrally which is occupied by the planum supraseptale". In discussing the bones around the orbit they state that they found a bony palpebral "not shown in Bellairs' (1950) figures". Bellairs shows nevertheless what is quite obviously the same bone in his fig. 1A labelled "so". His legend says "supraorbital (so) shown on one side only". He also figures it in transverse section, fig. 3C. The suggestion that the bone fell off in preparation, which could be true for a whole skull, does not make sense when we note that half of Bellairs's study was based on serial sections. They obscure what is probably a genuine difference between their material and that of Bellairs with regard to the postorbital bones by repeating the suggestion that bones fell off. I was interested to note that in the citation of Bellairs's paper (p. 139) his figures are not mentioned, a departure from the style otherwise adopted.

There is a good summary classification of the Anguinomorpha with a concise characterisation of each group. From a great mass of material of very uneven quality the treatment of the Anguinomorpha, the object of the work avowed on the title page, emerges as a sound and valuable contribution with scattered minor errors. It should serve well as a basis for further studies. The excellent plates considerably enhance the value of the work.

With regard to the affinities of snakes I feel that it is too early to settle upon the hypothesis of platynotan (or any other particular) affinities. There is still a need for workers in various fields to keep a lookout for evidence bearing on the affinities of snakes. The work of Hebard and Charipper (1954) on the histology of the adrenal glands of reptiles has quite recently brought out evidence bearing on the affinities of Squamatan families (and as it stands at present it does not seem to point to anguinomorph affinities of snakes). Dr. Hebard is extending his histological studies to the pancreas. A few comments of Miller (1948) on the pituitary strongly suggest that here is an almost virgin field for comparative studies of the Squamata which would yield interesting results. We are without any real knowledge of the comparative morphology of Squamatan hemipenes. Feeding and mating behaviour offers a field for systematisation of knowledge. Numerous further suggestions could be made. The case for separating the Typhlopidae from the snakes cannot stand but it draws attention to the aberrant condition of these rather poorly studied animals. I venture to express the hope that those making comparative studies of the Squamata will endeavour to include representatives of the Typhlopidae and Leptotyphlopidae.

The assessment of the status of *Lanthanotus* underlines Darlington's comment "Of lands that are still likely to yield new animals of zoögeographic importance, Borneo seems to come first". Darlington notes the occurrence of an *Ophisaurus*. Borneo may have been a

center of survival of ancient stocks some of which later dispersed into Sundaland. *Xenopeltis* and *Anomalochilus* occur there. It has recently been suggested that *Aeluroscalabates* represents the most archaic surviving stock of geckos (Underwood, 1955). Through the generosity of Dr. W. C. Brown I received material of *Dibamus*; preliminary study strongly suggests that its affinities lie with gecko-pygopod antecedents. Both these latter genera are found in Borneo. The recognition of the affinities of *Shinisaurus* gives us a distribution for the family Xenosauridae recalling that of *Alligator*. Perhaps relatives of the Xantusiidae will be found in Borneo or the far eastern mainland.

If half the work of McDowell and Bogert stand the test of time, after winnowing of errors, it will respresent an important contribution; if the other half be effectively refuted it will have stimulated progress.

For the material to which I have referred I am indebted to the Carnegie Corporation for the opportunity to collect *Cyclura* in the Turks and Caicos Islands, to Drs. G. L. Walls and K. S. Norris for *Leptotyphlops* material, to Dr. J. Hendrikson for *Xenopeltis*, to Mr. B. F. Rudeforth for *Aprasia* and to Drs. A. d'A. Bellairs and C. C. Shute for the other pygopods.

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Larval Development in New Jersey Hylidae

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THE absence of information on the variations in diagnostic characters in frogs from hatching to transformation has limited the use of larval material in distributional, ecological, and taxonomic investigations. Thus it is desirable to establish satisfactory criteria for separating the larval forms. Gosner and Black (1954) studied the variation in diagnostic characters of larval *Bufo woodhousei fowleri* and *Scaphiopus holbrooki holbrooki*. The present paper extends these studies to include the larvae of hylids in the New Jersey area, *Acris gryllus crepitans*, *Pseudacris nigrita feriarum*, *Hyla andersoni*, *Hyla crucifer crucifer*, and *Hyla versicolor versicolor*. The study is based largely on New Jersey material preserved in the Newark Museum. In addition, we are indebted to Mr. C. M. Bogert for permission to examine series of *Acris* and *H. andersoni* larvae in the American Museum of Natural History.

MATERIALS

The following larvae were examined: 100 *Acris gryllus crepitans* in 5 series from Cumberland and Sussex counties, New Jersey; Carbon County, Pennsylvania; and Long Island, New York; 376 *Pseudacris nigrita feriarum* in 37 series from Atlantic, Burlington, Cape May, Cumberland, Essex, Gloucester, Monmouth, Morris, Ocean, Sussex, and Union counties, New Jersey; 203 *Hyla andersoni* in 18 series from Atlantic, Burlington, Gloucester, Mon, mouth, Ocean and Salem counties, New Jersey, 512 *H. c. crucifer* in 39 series from Atlantic; Burlington, Cape May, Cumberland, Gloucester, Hunterdon, Monmouth, Morris, Ocean, Sussex, and Union counties, New Jersey; 167 *H. v. versicolor* in 13 series from Atlantic, Cape May, Cumberland, Monmouth, Morris and Sussex counties, New Jersey. All these specimens are in the collection of the Newark Museum except for the following which are in the American Museum of Natural History: *Acris*, AMNH 623, 19 specimens from Long Island, N. Y.; AMNH 51139-43, 44 specimens from Carbon County, Pennsylvania; and *H. andersoni*, AMNH 51299, 43 specimens from Ocean County, New Jersey.

The material examined represents various stages of development from hatching to transformation and includes field collections, as well as developmental series reared from eggs laid by frogs taken in amplexus or mated in the laboratory. All the local forms have been raised from hatching through transformation in the laboratory.

Measurements of head-body and total length on large specimens were made with a fine-pointed divider. The early stages, body proportions, and mouth parts were measured with a low power microscope fitted with an eyepiece micrometer disc.

Stages 15–24 in the development of *Hyla regilla* embryos are figured in Rugh (1952) who observes that they differ slightly from the equivalent stages of *Rana pipiens*, figured in Rugh, (1951). Stages in the metamorphosis of *R. pipiens* larvae are figured in the latter reference. In this paper we follow the procedure of designating embryonic stages by Arabic and larval stages by Roman numerals and have referred our staging to Rugh (1951).

LARVAL CHARACTERS

DIAGNOSTIC CHARACTERS FOR EARLY LARVAE.—Differences in size, color, and form of the adhesive organs readily separate local hylid larvae in embryonic Stage 20–25 from those of other anuran families (Gosner and Black *op. cit.*). Hylid hatchlings are light cream to dull brown in color, in contrast to the dark brown or black of local *Bufo*, *Rana*, (except *R. palustris* and some *R. virgatipes*), and *Scaphiopus*. The hylids are small in size, varying at Stage 20 from about 4.21 mm. in *H. c. crucifer* to about 5 mm. in *H. v. versicolor*, and in Stage 25 are less than 7.80 mm. *R. palustris* is similar to the hylids in color but is about 6.5 mm. at Stage 20 and 9 mm. at Stage 25.

The adhesive organs in local hylids are bifid at Stage 20. The scars deteriorate rapidly, persisting through Stage 25 but disappearing shortly thereafter. We were unable to detect them in 9.2 mm. *Acris* larvae or 14 mm. *H. andersoni*. The latter species retains vestiges of

adhesive organs somewhat longer than most of the other forms.

Noble and Noble (1923) describe and figure the development of the adhesive organs of *H. andersoni*, contrasting their more posterior position in this species with a more lateral position in *H. c. crucifer*. The other local species are similar to *H. c. crucifer* in having the organs placed more anteriorly. In *Acris*, particularly, the adhesive organs are in close contact with the developing oral disc. In *Pseudacris* and *H. c. crucifer*, at least, there is an indication of the presumably more primitive "U" shape of the developing organs at Stage 18.

The identification of local hylids at Stage 20 is difficult because of morphological similarity in the various species. The size at hatching (about Stage 20) differs in the individual species, and also varies in each. *H. c. crucifer* and *Acris g. crepitans* have the smallest hatchlings, which measure about 4 to 4.25 mm. at Stage 20. *Pseudacris* is sometimes slightly larger, reaching about 4.7 mm. *H. andersoni* and *H. versicolor* measure about 4.60 to 4.80 mm. at the same stage. At Stage 25, *H. c. crucifer*, *Acris*, and *Pseudacris* vary from 6.70 to about 7.55 mm. *H. andersoni*, while initially larger, is approximately equal to the above forms in total length at Stage 25. The *H. v. versicolor*, examined, varied from about 7.80 to 8.35 mm. at Stage 25. Because of individual variation relative size is of limited value in identification at this level of development.

Differences in the melanin pigment patterns of the tail musculature develop rapidly in the early larvae. *Acris*, at Stages 20–21 have a linear series of alternating dark and light spots on the dorsolateral surface of the tail musculature. This pattern occupies about one quarter of its dorsolateral surface. The remaining lateral surface is suffused with a dull melanin pigment. In life the light dorsal "squares" have a bright yellow to orange pigmentation that is soluble upon preservation. The contrast between dark and light squares in the pattern is further enhanced by creamy-yellow iridophores which are present as early as Stage 23. *H. c. crucifer* and *H. v. versicolor* typically have the tail musculature more or less unicolored, although *H. c. crucifer* is somewhat variable and may have the tail musculature more or less reticulated or even bicolored or striped at Stages 23–25. The striped or bicolored condition may persist through Stages I to IV or even longer in occasional variant specimens. A striped or bicolored tail musculature is characteristic of *Pseudacris* and *H. andersoni* larvae (Fig. 1).

DIAGNOSTIC CHARACTERS OF LATER LARVAE.—From the completion of the operculum to transformation, relative size correlated with the stage of development, oral structures, and body proportions, are useful for identification purposes.

The identification of northeastern anuran larvae at the family level is made by examination of the papillary border of the oral disc (Wright and Wright, 1949 and Gosner and Black, *op. cit.*). In local hylids the papillary border of the oral disc has a wide, median gap free of papillae on the upper labium; the papillary border is not emarginate (indented) laterally. In some *crucifer* larvae there is also a very short gap in the papillary border below the third lower tooth row. This gap is usually not present in

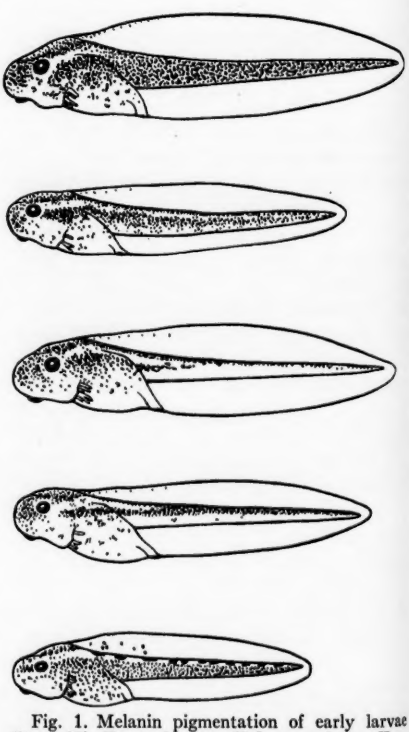

Fig. 1. Melanin pigmentation of early larvae (Stage 23). Top to bottom, *Hyla v. versicolor*, *H. c. crucifer*, *H. andersoni*, *Pseudacris n. feriarum*, *Acris g. crepitans*.

crucifer larvae with the tooth formula 2/2 and is not always present when the formula is 2/3. The family characters are established with the development of the first pigmented labial teeth.

The labial tooth formula of all the *Acris* and of nearly one third of the *H. c. crucifer* examined is 2/2. Different samples of *crucifer* vary in the frequency of individuals with the 2/2 formula. In a few lots of a dozen specimens or more all individuals have the 2/3 formula. Several other samples have 50 percent or slightly more of the individuals with 2/2. Usually there are a few specimens with 2/2 in any large sample. *Pseudacris, H. v. versicolor,* and *H. andersoni* have the labial tooth formula consistently 2/3. The minimum sizes that we have found for completion of the formula are; *Acris,* 8.5 mm.; *H. c. crucifer* 8.7 mm.; *Pseudacris, H. andersoni,* and *H. v. versicolor* between 10–11 mm.

A preliminary study was made in which seven oral characters were measured. To simplify comparisons, ratios of these characters were made using the length of the first upper tooth row as the divisor. The following is a summary of the normal relationships of these parts:

In all the local forms except *Acris,* the median, papillae free space on the upper labium is shorter than the first upper labial tooth row. In most *Acris* the two measurements are about equal or the median space is wider. The lateral elements of the second upper labial tooth row are individually longer than the gap separating them except in *Acris* where the reverse is true. The first and second lower labial tooth rows are subequal in length. The horny beak equals 40–60 percent of the length of the first upper tooth row except in *Acris* where it is usually equal to about 75 percent. The above statements are generally descriptive of local hylid larvae at maturity. Slight specific differences were observed in the various ratios but there is considerable individual variation. Differences in the length of the third lower labial tooth row are, however, of diagnostic value locally as indicated in the key. A study of the changes in oral ratios during growth indicates that these characters develop more or less allometrically. The importance of comparing specimens in equivalent stages of development is obvious.

Differences in melanin pigmentation on the tail musculature and fins are of use in separating local hylid larvae. The differential patterns begin to take form shortly after hatching and specific differences appear to remain fairly constant during the entire larval period. The melanin pigmentation of the tail fins is also distinctive when fully developed but these characters change considerably during growth. Details are given in Fig. 2 and in the Key.

Color differences due to lipophores (mainly dull yellow hues) and iridophores (which produce brilliant iridescent and metallic effects) are of limited use for identification of preserved larvae since they disappear or are radically altered by preservation. Iridophores (or guanophores) appear at least as early as embryonic Stage 23 in the iris and as scattered flecks elsewhere on the body.

The darkness or lightness of individual lots of tadpoles may vary according to environmental conditions. Groups reared in transparent dishes under moderate light are usually lighter than specimens from the field particularly when the latter come from habitats with a dark substratum. The integument is quite transparent during the early larval period and visceral elements play an important part in "pattern" formation.

In life the highly saturated orange-red color in the tail fins of *H. v. versicolor* larvae is distinctive. This coloration did not develop in laboratory-reared groups and in field collections was not noticeable until larvae reached about half their full growth. We have not observed this red coloration in any other local hylid larvae but according to Wright and Wright (*op. cit.*) it occurs in *H. femoralis* and *H. arenicolor.*

The head outline as seen from above provides a useful clue to family identification in the field. The eyes of local hylid larvae are located on the lateral margin of the head and the cornea are visible at least slightly when larvae are viewed in ventral aspect. Among local ranids, *R. s. sylvatica* approaches the hylid condition. In *Acris* and in local ranids generally the eyes are usually within the lateral margin and the cornea are not visible from below. The head-body outline is generally more nearly "tear drop" in shape in the ranid type larvae. These differences are illustrated in Fig. 3. The outline of local *Scaphiopus* and *Bufo* larvae have been figured in Gosner and Black (*op. cit.*); the eyes are placed well within the margin of the head.

A preliminary study was made in which ten

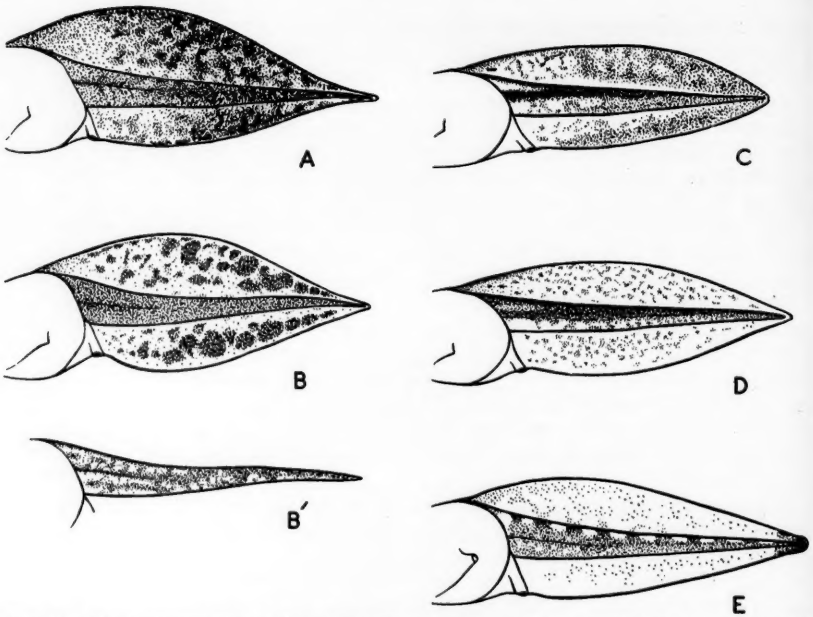

Fig. 2. Melanin pigmentation of the tail of mature larvae. A, *Hyla v. versicolor*; B, typical and B′, variant *H. c. crucifer*; C, *H. andersoni*; D, *Pseudacris n. feriarum*; E, *Acris g. crepitans*.

head-body proportions were measured. To simplify comparison, ratios of these characters were made using the body length as the divisor. The characters develop more or less allometrically, and with considerable individual variation. The following characters provide useful ratios for species differentiation; snout to spiracle distance, interocular distance (from dorsal margin of pupils), width of the oral disc, and inter-nasal distance.

Fig. 4 shows the relationship of larval stages to total length. Size-stage curves were obtained by plotting the mean total length at each stage. The curves are based on a minimum of 100 specimens for each species except in the case of *Acris* where only 69 specimens were available. The largest specimens (total length) were as follows: *Acris g. crepitans*, 43.5 mm.; *Pseudacris n. feriarum*, 30 mm.; *H. andersoni* 43.3 mm.; *H. c. crucifer*, 34 mm.; and *H. v. versicolor*, 42 mm. The ratio, total length/head-body length is subject to considerable individual variation. For the purpose of establishing the size-stage relationship in damaged material we have used an arbitrary value for this ratio of 2.65. The observed range in local hylids was 2.48 to 3.20, with the means ranging from 2.60 *Pseudacris* to 2.72 in *Acris*.

Changes associated with transformation affect the coloration, mouth parts, and proportions of the larvae. Changes occur in the texture of the integument and the pigmentation of the head and body anticipates the adult pattern.

Newly transformed individuals of all species except *H. versicolor* resemble the adult in pattern. *H. versicolor* larvae that we examined transformed without developing markings suggestive of the pattern of the adult. The specimens were more or less uniformly dull greenish or olive with some darker reticulations or speckled markings on the hind limbs.

Transformation sizes given by Wright and Wright (*op. cit.*) are *Acris g. crepitans* 9–15 mm., *Pseudacris n. feriarum* 8–12 mm., *H andersoni* 11–15 mm., *H. c. crucifer* 9–14 mm., and *H. v. versicolor* 13–20 mm. Our figures fall within these ranges.

Our earliest field records for transformation in New Jersey are: *Pseudacris* May 31, *H. andersoni* June 25, *H. c. crucifer* May 30, *H. v. versicolor* June 25. The length of the larval period in groups reared at room temperature

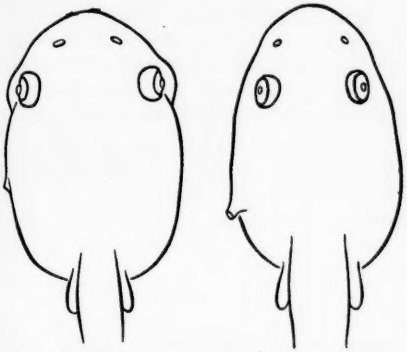

Fig. 3. Mature larva of *Pseudacris n. feriarum* (left) and *Acris g. crepitans* (right) in dorsal aspect.

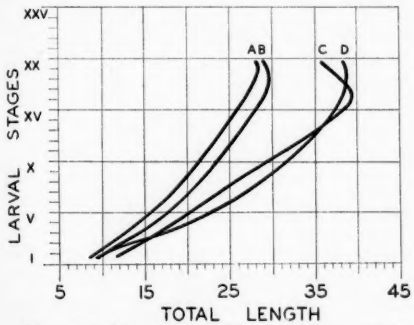

Fig. 4. Relationship of larval stages to total length (in mm.). A, *Pseudacris n. feriarum*; B, *H. c. crucifer*; C, *H. andersoni*; D, *H. v. versicolor*. The curve for *Acris g. crepitans* is approximately equal to D.

was; *Pseudacris* 29–33 days, *H. andersoni* 48 days, *H. c. crucifer* about 35 days, *H. v. versicolor* 31 days, and *Acris* 60 days. The estimated length of the larval period in the field is; *Acris* 50–90 days with transformation in August and September, *Pseudacris* 40–60 days with transformation from May 25 into July, *H. andersoni* 50–75 days with transformation from June 20 through August, *H. c. crucifer* 40 to 60 days with transformation from May 25 into July, and *H. v. versicolor* 40 to 60 days with transformation from May 25 through July or early August.

Summary

The family characters for the hylid larvae in the New Jersey area in embryonic Stages 20–25 are: size, small with Stage 20, 4.21–5 mm.; Stage 25, 6.85–8.35 mm.; color pale buff to dull brown. Hylid larvae (after Stage 25) have the papillary border of the oral disc with a broad median gap on the upper labium (also in some *H. c. crucifer* a very short gap below the 3rd lower labial tooth row). The papillary border is not emarginate. The following key is a resume of the characters used to identify hylid larvae in the New Jersey area:

I. At Hatching
  A. Size small, with Stage 20 usually less than 4.65 mm., Stage 25 usually less than 7.5 mm.
    1. Tail musculature marked dorsolaterally with a linear series of well defined dark and light rectangular spots. Eggs laid singly, submerged, in May and June..... *Acris g. crepitans*
    2. Tail musculature often uniformly colored in Stage 20, later with a dark lateral stripe or bicolored. Eggs laid in small packets often at or near surface, usually before May 1. *Pseudacris n. feriarum*
    3. Tail musculature uniformly pigmented laterally or irregularly mottled, occasionally somewhat bicolored or striped. Eggs laid singly, submerged, usually before May 1 but possibly as late as first week in June. *Hyla c. crucifer*
  B. Size larger, with Stage 20 usually more than 4.65 mm.
    1. Tail musculature with an oblique dark stripe laterally; size in Stage 25 about 7.1 mm. Eggs laid singly, submerged, usually after May 1. *H. andersoni*
    2. Tail musculature uniformly pigmented laterally or irregularly mottled; size in stage 25, 7.80 mm. or larger. Eggs laid in packets at surface, usually after May 1. *H. v. versicolor*

II. After Stage 25 (for size-stage relationships see Fig. 4)
  A. Tail musculature marked dorsolaterally with a linear series of dark and light rectangular spots; tail frequently black at tip; spiracle a short projecting tube; labial tooth formula 2/2; eyes within lateral margin of head in dorsal aspect with interpupillary distance equal to .45 or less in body length; horny jaws

equal, .70 or more in first upper labial tooth row. . . . . *Acris g. crepitans*

B. Tail musculature bicolored or with a well defined lateral stripe; tail fins usually relatively narrow; labial tooth formula 2/3; without other characters in A.

1. Size smaller; tail musculature usually bicolored or, when striped, with the stripe nearly parallel to the long axis of the tail; tail fins with scattered melanophores and not usually blotched; head broad with interpupillary distance .49 or more in body length or with product of interpupillary ratio and oral disc ratio equal to 1.10 or more; 3rd lower labial tooth row shorter, equal to less than .30 in first upper tooth row.

Pseudacris n. feriarum

2. Size larger; tail musculature usually with a well defined lateral stripe meeting the long axis of the tail at an oblique angle; tail fins often with much dark pigment and blotched in full grown larvae; head and body narrower with interpupillary distance usually less than .49 in body length or with product of interpupillary ratio and oral disc ratio equal to 1.10 or less; 3rd lower labial tooth row longer, usually more than .30 in first upper tooth row. . . *H. andersoni*

C. Tail musculature usually more or less uniformly pigmented or with irregular blotches or reticulations; tail fins usually relatively deep; labial tooth row formula 2/3 or sometimes 2/2; without other characters in A.

1. Size smaller; snout-spiracle distance usually .70 or more in body length; body narrower and oral disc smaller with mean product of interpupillary ratio and oral disc ratio equal to about 1.20; 3rd lower tooth row very short, shorter than median gap in 2nd upper labial tooth row or sometimes absent; tail fins heavily blotched with dark. . . *H. c. crucifer*

2. Size larger; snout-spiracle distance usually less than .70 in body length; body wider and oral disc larger with mean product of interpupillary ratio and oral ratio equal to about 1.30; 3rd lower labial tooth row wider than median gap in 2nd upper labial tooth row; tail fins heavily blotched with dark and frequently with red-orange pigmentation in life. . . *H. v. versicolor*

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Variation in Colors and Color Patterns in Tadpoles in Oklahoma

Arthur N. Bragg

Color and color patterns have been used extensively in the identification of tadpoles. Nearly every key for identification of larvae has used such characters as the distribution and amount of pigment in the tail fins. In my own key (Bragg, 1950), for example, *Hyla versicolor versicolor* and *Hyla crucifer crucifer* were distinguished on whether "marginal concentration of pigment [in the tail fin is] essentially in blotches" or "practically a con-

tinuous line" and there are several other places where color or color pattern is used to distinguish between two species or groups.

During the past few years I have collected thousands of tadpoles throughout Oklahoma from various types of water and have noted so much color variation that I have come to question the validity of the use of color in distinguishing tadpoles. For example, the tadpoles of *Bufo cognatus* Say were earlier described as having an essentially clear tail fin (Bragg, 1936) with only a few small pigment spots dorsally in some individuals. The clear tail fin is typical; but in one place at Norman, Oklahoma, during the spring of 1954 (and at this and another site in 1955) the fins were extensively mottled both dorsally and ventrally. Coupled with this, the whole animal was very dark and some individuals were almost as black as the tadpole of *Bufo terrestris americanus*. Some years ago tadpoles of *Rana pipiens berlandieri* which were almost black and which had heavily mottled tails were found in one pool, whereas in a second pool they were totally different—a light greyish brown with clear fins. Both pools were temporary and only a few rods apart on the same slope; but the first was shaded by oak trees and the water heavily stained by materials leached from oak leaves on the bottom whereas the second pool was surroundcd by grasses and the water was turbid.

Tadpoles of *Scaphiopus bombifrons* in central Oklahoma are grey in some pools, brown in others. But in many places in western Oklahome they are light-cream colored and in some pools they are white. Tadpoles of the *Hyla versicolor* group are well known to develop large black splotches in the tail fin and to have a brilliant red color in posterior portions of the tail a few days before metamorphosis. Yet in some pools where hundreds and probably thousands are present, none develops the red condition. In one such pool hylid tadpoles with red tail have not been found in several years of study. In another, in central Oklahoma, usually about half of those present each year develop the red tail. In a second pool in this region, about two-thirds of the tadpoles develop the red in the tail. These are only a few samples among many. Coloration in tadpoles in general seems to be the result of a complex of factors; some genetic, some hormonal, and others environmental. Naturally, field studies are mostly limited to what can be learned concerning the effect of environment with some reasonable inferences as to the effect of genetic factors.

In clear, shallow, unstained pools with a dark bottom, tadpoles of most species known to me tend to be darker in color than in turbid waters. For example, on May 13, 1949 a large ditch of clear water near Snyder, Oklahoma, contained thousands of tadpoles of the southern spadefoot, *Scaphiopus couchi*, which were in the first stages of metamorphosis. The classic description of tadpoles of this species includes references to golden or bronzy sheens. These tadpoles, on the contrary were very dark, almost black dorsally, with no more iridescence than commonly found in any healthy live tadpole not usually thought of as having a sheen. In another pool, in the Wichita Mountains of Commanche County, Oklahoma, also clear and shallow, tadpoles of this species were quite dark but with a peppering of tiny silver spots and little iridescence. On the other hand, tadpoles of this species developing in a culture dish of clear tap water in the laboratory produced golden sheens and metamorphosed later as wholly golden and very beautiful little spadefoots.

In several buffalo wallows where the bottom was of light reddish clay and the water clear, the tadpoles of *Bufo cognatus* were dark grey with clear tail fins, as earlier described (Bragg, 1936). But in a field pool in the same region of central Oklahoma, heavily shaded with tall grasses protruding through the water, they were almost black.

Even our dwarf American toad (*B. terrestris charlesmithi*), whose tadpoles are characteristically very black, may vary in coloration in some clear waters. In one pool, 9 miles east of Norman, Oklahoma in 1954 and 1955 these tadpoles were dorsally spotted and mottled in greys and browns, though still very dark. I have never seen them other than black elsewhere.

The intensity of dark pigment is enhanced in clear, stained waters. For example, the blackish tadpoles of *Bufo cognatus* mentioned earlier lived in two such pools. They were accompanied by many tadpoles of two other species, *Microhyla carolinensis olivacea and Pseudacris clarki*, all of which were fully as dark as those of the *Bufo*. The microhylas were also all spotted and streaked ventrally. In contrast, the tadpoles of *P. clarki* taken from a muddy ditch approxi-

mately four miles away on the same day had the characteristic light grey coloration given in the original description (Bragg, 1943).

Turbid waters, as in many cattle tanks and ditches, almost always produce light tadpoles, although, if shaded, the animals may be darker. Tadpoles which tend genetically to be dark are often exceptions although even these are sometimes lighter than accounts of them in the literature leads one to expect. But turbid water is not the whole explanation, at least in many cases. For example, the plains spadefoot, *Scaphiopus bombifrons*, often breeds in such waters. In clear water in central Oklahoma they are dark to medium brown. In turbid waters in the same region they are light brown to light grey. But in western Oklahoma in pools of turbid water they are cream-colored as earlier noted but may be darker in ditches with clear water.

Recently Mr. Frank King of Norman brought me nine brown *Scaphiopus bombifrons* tadpoles from a shallow terrace ditch on the farm of Mr. F. M. Marble located in prairie at the edge of the oak-hickory savannah in central Cleveland County, about seven miles northeast of Norman, Oklahoma. The bottom of the ditch was of grey clay and the water was clear. The coloration of these tadpoles included an unusual dorsal sheen. There was a sharp contrast laterally between the darker dorsal and lighter ventral coloration instead of the usual gradual shading of one into the other. They were placed in an aquarium with a dark bottom and left in about three inches of clear tap water in a well-lighted room. A few days later six of them went into metamorphosis. As they did so, each developed a series of large, rounded, dark brown spots along the dorsum, as do young *Bufo cognatus* at the same stage, except that in the latter the spots are paired. The spots on the spadefoots were generally arranged in three rows, one down the middle of the back and one on each side. The most anterior spot of the middle row on each animal differed from the other spots in that it was larger and shaped like a broad triangle with its apex pointed posteriorly; in position (just behind the eyes), shape, and size they resembled closely similar spots on adults of *Pseudacris streckeri streckeri*. The spots persisted until well after metamorphosis but were gradually lost when the animals were transferred to a container of wet black earth as each individual darkened to conform to the new environment. Two tadpoles of this group delayed metamorphosis for several weeks but when they finally transformed developed the dorsal spots as the others had done.

Tadpoles of *Scaphiopus holbrooki hurteri* have been studied each year, 1945 through 1955, in two or more of seven temporary pools in Cleveland County, Oklahoma. Four of these pools are turbid when first formed by rains but gradually clear. Tadpoles from these pools are always lighter than those from a pool which remains clear but stained throughout its existence. Tadpoles from this clear pool and those from two other pools which clear more rapidly than the first four, typically develop a small light yellowish bar across the dorsal portion of the tail base, never seen among the thousands developing in the more turbid water.

Marked variation in coloration in tadpoles of *Rana areolata* (both subspecies) was noted earlier (Bragg, 1954), in this case obviously correlated with the marked tendency of the animals to remain in cover of various kinds.

In the emphasis on color variation in different waters, we must not overlook genetic factors. Irrespective of environment, some tadpoles tend to be dark, others light. Some tend to have a characteristic of the color pattern which is quite distinctive. For example, all but a few *Microhyla* tadpoles develop a black tail tip. The same is true of *Acris crepitans*, in which the black tail tip is almost invariably present, even on very young tadpoles, although smaller in extent than on *Microhyla*.

It would seem, therefore, that the following conclusions may be drawn:

(1) Tadpoles of most species tend genetically to have a characteristic color, color trend (light or dark), or color pattern fairly distinctive of each.

(2) The characteristic coloration, however, may be slightly or greatly modified by environmental influence.

(3) In some species (e.g., *Bufo terrestris charlesmithi*) the general coloration is usually unmodified by environment and only comparatively slightly so when it is modified. In others (e.g., *R. areolata*, *Pseudacris clarki*, *Bufo cognatus*, and *Scaphiopus bombifrons*) it varies greatly with variations in the environment.

(4) As a general rule, the darker the tadpole

genetically the less apparent is the modification by environmental factors.

(5) Some of the environmental factors involved are (or are associated with) (a) the amount of light available from above, (b) the general color shade (dark or light) of the pool bottom, (c) staining of the water by materials leached from plants or their leaves, (d) colloidal clay or other particles in large amounts suspended in the pool, (e) kind of materials used as cover (at least in *R. areolata*), and probably (f) temperature. Combinations of these factors, working together, are the rule in most cases.

(6) The partial environmental control of tadpole coloration is adaptive, tending to conceal the tadpoles in their native pools, whatever the type of pool may be in an individual case.

(7) Within the genetic limits (point 1, above) tadpoles of all species in a single pool tend to be lighter or darker as the case may be. That is, environmental factors work the same way on each species of tadpoles in the pool.

(8) From the above, it follows that in making keys to tadpoles great care should be taken in using color or color patterns.

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Viability of Lizard Eggs Exposed to Sea Water

Walter C. Brown and Angel C. Alcala

The manner of dispersal of reptiles occurring in such island areas as those of the Pacific Ocean has frequently been a matter of speculation. One method, presumably open to oviparous species, is that of waif dispersal of the eggs by means of logs or other flotsam. Certainly the laying habits of many lizards, including those species with which the present study is concerned, make this means highly plausible and fragmentary observations have at times lent support to the hypothesis. Dammerman (1948) comments on the finding of eggs of *Hemidactylus frenatus* in hollows of a decayed tree trunk on the beach of Karakatau Island in February, 1928. These eggs were viable and he succeeded in hatching them. Since the origin of the log was not known, however, the extent to which the eggs had been exposed to sea water was also unknown.

One aspect of this problem, viability under simulated conditions of exposure to salt water, as in the case of certain plants (Martins, 1857; Edmondson, 1941; Whitaker and Carter, 1954), is subject to experimental attack. Preliminary experiments, using the eggs of four species of Philippine lizards, were carried out by the authors at the Biological Laboratories, Silliman University, during the period from January to May, 1955.

Materials and Methods.—Eggs of *Cosymbotus platyurus, Gehyra mutilata, Hemidactylus frenatus* and *Dasia smaragdina philippinica* were used in the experiment. Those of the first three species were found in the bamboo poles or nipa palm shingles of native houses and also beneath the bark of trees both near and far removed from human habitation (These latter sites probably did not include eggs of *Cosymbotus*). The eggs of the scincoid lizard, *Dasia smaragdina*, were obtained from the pulpy wood of decaying stumps of both coconut and dicotyledonous trees.

A total of 66 eggs was collected on seven different occasions between January 6 and March 30, 1955. Of these 31 were exposed to sea water under conditions that may simulate the degree of exposure to which such eggs might normally be subjected under rafting conditions

and 35 were used as controls and underwent the same laboratory treatment other than the exposure to sea water. The number of eggs collected in each instance and the number exposed to sea water (in parenthesis) were as follows: 8 (4), 1, 11 (5), 17 (9), 3 (3), 14 (7), 12 (3). The eggs were numbered for identification and the control eggs of the gekkonoid species were placed in watch glasses in the bottom of screened culture jars. Control eggs of *Dasia smaragdinum* were buried in damp, rotting wood pulp in a screened culture jar. Eggs to be exposed to sea water were each placed in a small gauze sack so designed that the bottom portion (about one inch in length) was tied off beneath the egg. These sacks were then hung over the edge of a glass tumbler, which was partly filled with sea water, in such a manner that the bottom portion of the sack served as a wick maintaining a thin film of sea water on the surface of the egg without the latter being immersed. Sea water was added to the tumbler every six to twelve hours in order to maintain the level of the water high on the wick, close to, or occasionally in contact with, the lower surface of the egg. Under these conditions the surface of the eggs were at no time observed to be dry. As the humidity was generally high, the loss of water from the glass appeared to be primarily due to siphoning rather than evaporation and it tended to collect in the bottom of the dish in which the glass was placed. Therefore the probable slight increase in the concentration of salts in the tumblers during the course of the experiments was ignored. The experimental eggs of the gekkonid lizards were removed from their gauze sacks after intervals of one day to eleven-plus days of exposure and were placed in watch glasses in the culture jars containing the control eggs. The eggs of *Dasia smaragdina* were removed from their gauze sacks after periods of three to five days and placed with the control eggs. The eggs of the three gekkonid species were not identifiable as to species (in the light of our present knowledge) prior to hatching and are considered as a unit when viability of control and experimental groups is compared (Table 1).

RESULTS AND DISCUSSION—Considering only the gekkonid species, the results of the experiment indicate a lowered viability (Table 1) under the conditions of exposure imposed which, it is believed, may simulate more or less constant exposure to sea spray. The probability that the observed differences in viability of control and experimental groups was due to chance is less than 0.01 (based on a Chi-square test).

	Control group		Experimental group	
	Observed	Expected	Observed	Expected
Viable.....	25	20.2	14	18.8
Did not hatch.....	5	9.8	14	9.2

However, under these conditions, the hard-shelled eggs of one of these species, *Gehyra mutilata*, remained viable for a period of at least 11 days, the maximum period of exposure tested in the present experiment. Pending further experimental data, there is no reason to assume that the period of viability may not in some instances be much longer, possibly approaching the length of the incubation period, seventy-plus days for *Cosymbotus platyurus* and

TABLE I

VIABILITY OF LIZARD EGGS EXPOSED TO SEA WATER

Species	No. of control eggs hatched	No. of exposed eggs hatched	Periods of exposure for viable eggs
Gehyra mutilata	15	8	96 to 268 hours
Hemidactylus frenatus	6	2	50 to 168 hours
Cosymbotus platyurus	4	4	48 to 192 hours
Percent of total	25 out of 30 (83.3%)	14 out of 28 (50.0%)	
Dasia smaragdina philippinica	5	0	
Percent of total	5 out of 5 (100%)		

Hemidactylus frenatus and forty-nine-plus days for *Gehyra mutilata* according to our present observations. Nor is there any reason at the present time for assuming any substantial differences in the viability of the eggs of these three species since they were not identified as to species but treated as a group during the period of exposure. The effect of the extent of development at the time of exposure upon viability can not be determined at this time, but it is tentatively held that this may not be of great significance since one egg of *Hemidactylus frenatus* which was exposed to sea water for 168 hours had an incubation period of 56 days, one egg of *Cosymbotus platyurus* so exposed for 48 hours had an incubation period of 70 days and one of *Gehyra mutilata* exposed for 216 hours had an incubation period of 41 days. Although we do not know the maximum period of incubation for these species or the possible effect on rate of development of such a variable as temperature, we think it is safe to assume that these eggs were probably in early or middle stages of development in the light of observations as to the incubation period of related species (Ahl, 1930: 626; Cagle, 1946: 9; Oliver and Shaw, 1953: 88).

The leathery-shelled eggs of *Dasia smaragdina* which were exposed to sea water for 72, 93 and 117 hours respectively were shrunken as a result of dehydration to the extent that none of them were viable apparently, whereas all five control eggs hatched in one to 24 days.

These results suggest that the eggs of the three gekkonid species studied might feasibly survive waif transport under conditions where they are more or less constantly wet by sea spray for a period of at least 11 days and probably longer, and that the eggs of *Dasia smaragdina* are no longer viable after relatively shorter periods, 3 to 5 days, when similarly exposed.

Acknowledgments

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The Thyroid Gland of *Typhlomolge rathbuni*[1]

Aubrey Gorbman

THREE endocrine conditions have been held responsible for retention of larval characters in different neotenous amphibian species (Lynn and Wachowski, 1951; Kezer, 1952). In one type (e.g. *Necturus*, *Proteus*) the tissues appear to be insensitive to thyroxine. In a second (axolotl) the tissues are sensitive, but there appears to be a failure of thyroxine formation by the thyroid. Emerson (1905) and Uhlenhuth (1923) are frequently cited as having demonstrated a third type, limited to a single species *Typhlomolge rathbuni*, which lacks thyroidal tissue altogether.

This remarkable claim would establish *Typhlomolge* as the only vertebrate which lacks a thyroid gland. Although this idea seems to have gained general acceptance in

[1] This study was aided by a grant from the National Science Foundation.

recent reviews, it was met with considerable argument at the time of publication of Uhlenhuth's extensive article on the subject (Uhlenhuth, 1923). Furthermore, critical examination of Uhlenhuth's data shows that although he describes *Typhlomolge* as being "athyroid", he presents several text illustrations of "thyroid remnants" which, nevertheless, appear to be rather typical thyroid tissue containing colloid.

Because of the importance of an unequivocal answer to this question it is surprising that it has remained for so long in this state. Perhaps one of the most potent factors in preventing additional work with *Typhlomolge* is its highly restricted distribution. It is known only from Hays, Kendall, and Comal counties Texas where it lives in caves and artesian wells.

Through the kindness of C. M. Bogert of the American Museum of Natural History, two alcohol-preserved specimens of *Typhlomolge* were made available to me. These had been collected in 1903 from an artesian well by members of the "U. S. Fish Commission". They appeared to be in a fairly good condition. The total lengths of the animals were 81 and 135 millimeters, respectively. The lower jaws were dissected off to include all the tissue anterior to the heart. They were refixed for 48 hours in Bouin's fluid and then serial sectioned by the paraffin technique. A fairly satisfactory haematoxylin-eosin stain was obtained. Other than a brittleness of the tissue no difficulty was encountered despite the 52 years in 70 percent alcohol.

Study of the serial sections soon revealed that thyroid tissue of fairly typical histological characteristics was present in both lower jaws. It was unusual only in being located almost entirely on the right side. In one animal no thyroid follicles were seen on the left side; in the other, a small number of follicles—about 15—were found on the left. Some of the follicles were so small that it was difficult to distinguish their lumina. For this reason it was difficult to decide upon the number of follicles in each of the two specimens studied. It was estimated, however, that the total number was near one hundred.

A second unusual anatomical feature was the location of the thyroid tissue in relation to the branchial arches. Whereas the usual position in urodeles is anterior to these arches, in our specimens of *Typhlomolge* there were two antero-posteriorly distributed masses of thyroid tissue. One of these was in the normal anterior position, applied to the dorsolateral surface of the rectus cervicis muscle (Pl. I, 1). The larger, more posterior one was behind the branchial arches, closely applied to a small branch of the external jugular vein. This vein extended dorso-laterally from the external jugular from a point near the bulbar region of the heart. Thyroid follicles occurred in a tract following the vein between the rectus cervicis and transversus ventralis muscles[2] to a superficial position in the connective tissue under the epithelium of the mouth (Pl. I, 2).

There was relatively little connective tissue condensed about the thyroid tissue in the form of a capsule (Pl. I, 3) except at the posterior extremity of the posterior follicular group (Pl. I, 4). Here there was a rather thick encapsulating layer.

Histologically the gland presented no unusual morphological features. The follicles were relatively small, and lined by a cuboidal or squamous epithelium. Colloid was present but stained weakly with eosin. In the lumen of a few follicles the stain was slightly heterochromatic. The colloid completely filled the follicles and showed none of the "vacuoles" which are found near the cellular border of the colloid in active thyroids. Nuclei in the follicular cells stained darkly and appeared uniformly colored. It is probable that the relatively structureless character of the nuclei and the chromophobia of the colloid may have been due to imperfect fixation and, in part, to the long residence in alcohol. In only one follicle in one of the two specimens were there seen cells within the colloid. These cells appeared to be erythrocytes and leucocytes.

Discussion

In view of the finding of close to 100 thyroidal follicles in each of two *Typhlomolge* examined, it seems difficult to continue the notion that this species is "athyroid", as claimed by other authors. It is quite clear, however, that on morphological grounds, at

[2] I am indebted to Dr. Arthur Rempel, Whitman College, Walla Walla, Washington, for aid in identifying the muscles in the region of the thyroid of *Typhlomolge*.

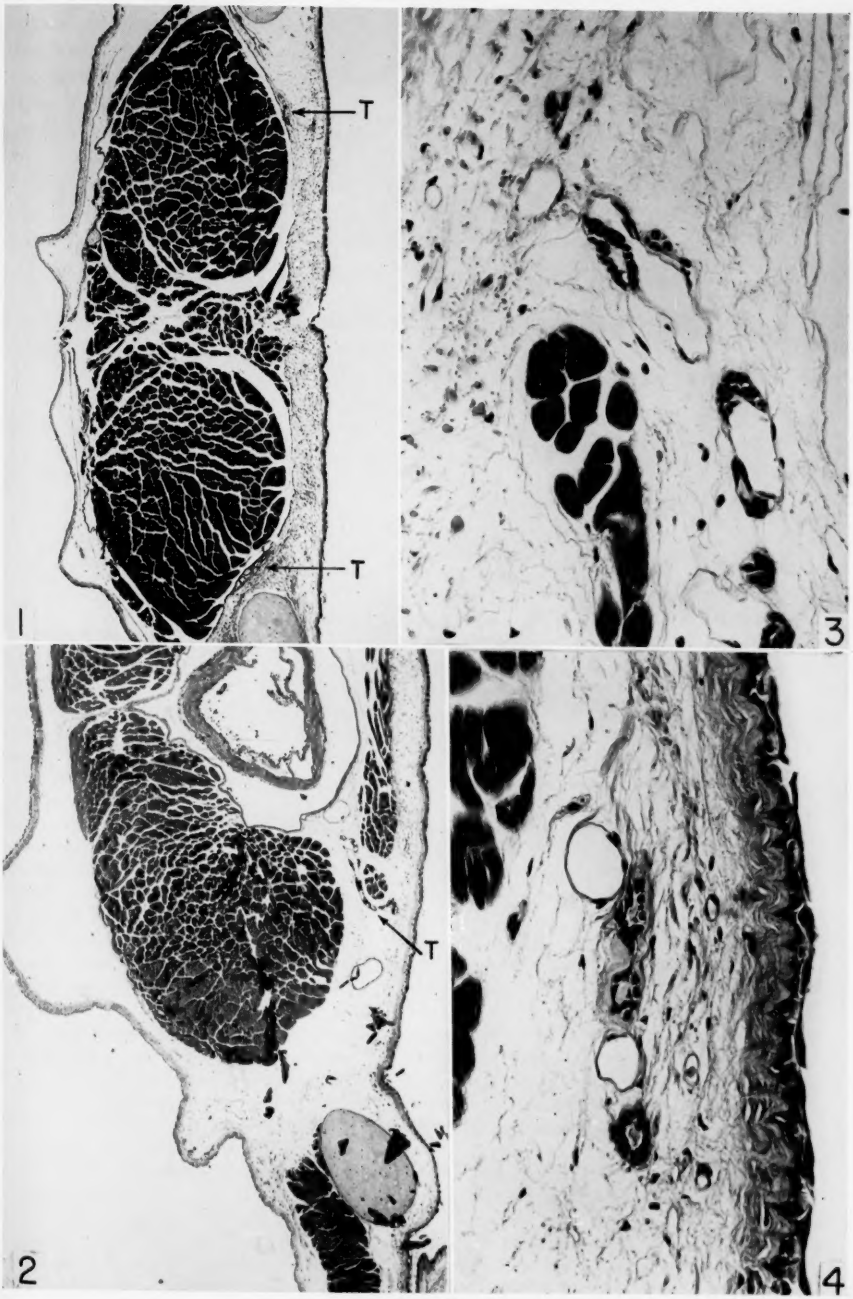

PLATE I

The thyroid tissue of *Typhlomolge*

least, the thyroidal tissue appears inactive. This is inferred from the height and staining of the epithelial cells, and the unvacuolated character of the colloid.

It would appear from the microscopic evidence, then, that the neoteny of *Typhlomolge* is not due to absence of thyroidal tissue. It will be of interest to submit this species to experimental investigation to show whether its tissues are responsive to thyroxine and whether its thyroid does, or is able to, form the hormone. In a personal communication W. F. Blair states that in experiments conducted in his laboratory, *Typhlomolge* did not respond observably to immersion in thyroxin solutions. However, Kezer (1952) and Dent, Kirby-Smith, and Craig (1955) have found the neotenic salamanders *Eurycea tynerensis*, *E. neotenes* and *Gyrinophilus palleucus* sensitive to thyroxine.

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Herpetological Notes

DISTRIBUTIONAL NOTES ON GEORGIA AMPHIBIANS, AND SOME CORRECTIONS.—Georgia includes portions of five major physiographic regions and Atlantic, Gulf and Mississippi drainages are represented within its borders. Its herpetofauna is correspondingly diverse, and incompletely known. I present here notes accumulated during nearly 20 years' study and collecting in Georgia, and comment on some recent herpetogeographic errors and omissions.

Counties mentioned in the following accounts are in Georgia, unless otherwise stated.

Cryptobranchus a. alleganiensis.—Martof (1955, COPEIA (3) : 166) reported one specimen, possibly introduced, from a tributary of the Oconee River in Barrow County. He stated that all previous Georgia records were from the Tennessee drainage. However, Bishop (1943, Handbook of Salamanders: 60) indicated the presence of the species on the Savannah. In correspondence he explained to me that there were a few old specimens of the hellbender from Anderson and Abbeville, on the South Carolina side of the Savannah drainage. Firschein (1951, Amer. Midland Nat., 45 (2) : 458) stated that coastal streams of Georgia were inhabited in their upper headwater regions. The Tennessee is not a coastal stream; Firschein's comment probably referred in part to the Savannah. I collected a hellbender (No. 15653 in the collection of E. Ross Allen and Wilfred T. Neill) in a tributary of the Savannah near Wylie, Rabun County, which helps to verify earlier records.

Ambystoma mabeei.—Bishop (*op. cit.*: 136) stated that the first example of this species was taken by W. B. Mabee in 1923. However, Cope's account of "*Amblystoma conspersum*" (1889, The Batrachia of North America: 61–62) was based on *Ambystoma mabeei*. (The type of Cope's *conspersum* was a small *A. tigrinum*, and so the name *mabeei* stands; see Dunn, 1940, COPEIA (3) : 154.) Two of Cope's *A. mabeei* were sent to the Academy of Natural Sciences of Philadelphia by John Le Conte, who resided at Riceboro, Liberty County. Accordingly, recent authors have extended the range of Mabee's salamander southward into Liberty County. Unfortunately, many specimens shipped from Riceboro probably were not collected there; examples are *Gyrinophilus danielsi dunni*, *Desmognathus f. fuscus*, and *Rana p. pipiens* in the U. S. National Museum collection. The Georgia record of *A. mabeei* is therefore questionable, especially since it has remained unverified for about 70 years. The nearest definite locality for the species, so far as I know, lies roughly 100 miles to the northeast, in Charleston County, South Carolina.

Ambystoma mabeei and *A. cingulatum* are very similar in habits and habitat; they also yield to the same collecting techniques. I have been successful in collecting *A. mabeei* in South Carolina, but in Georgia have found only *A. cingulatum*.

Desmognathus a. aeneus.—Martof and Humphries (1955, COPEIA (3) : 245) reported this species in northern Georgia, and said that theirs were the only records for the state. However, this salamander had previously been placed on the Georgia list (Neill, 1949, A Checklist of the Amphibians and Reptiles of Georgia: 1); several Georgia records were cited by Barry D. Valentine in a talk, "Studies on the Variation and Distribution of the Pigmy Salamanders of the genus *Desmognathus*," given before a meeting of the ASIH, Southeastern Division, at the University of Alabama in 1952; and the presence of the species in Rabun, Union, and Gilmer counties have been noted (Neill, 1954, Pubs. Research Div., Ross Allen's Reptile Institute, 1 (7) : 80).

Plethodon dorsalis.—This species has not been previously reported from Georgia. On April 28, 1948, 12 examples were collected at a locality about one mile southwest of Trenton, Dade County. They were found within a radius of nine yards, beneath small rocks and debris on a rocky outcropping. These salamanders (ERA-WTN 12128) are unusual in several respects. The dorsal light stripe exhibits every degree of intermediacy between the zigzag condition, typical of *P. dorsalis*, and the straight condition characteristic of *P. c. cinereus*. In three the dorsal stripe is strongly zigzag, in eight weakly to faintly serrated, and in one nearly straight. The costal groove count is likewise variable, and not simply as a consequence of preservation; for Richard Highton, of the Department of Biology, University of Florida, made X-ray photographs of all these specimens and found a corresponding variation in the number of rib-bearing vertebrae anterior to the pelvis. The vertebral count was 18 in one specimen, 19 in ten, and 20 in one. A high vertebral count of 20 is unusual in *P. dorsalis* but not in *P. c. cinereus*. The example with a *cinereus*-like vertebral count is also the one with a straight, *cinereus*-like dorsal stripe. Taken individually, this salamander would be identified as *P. cinereus* by anyone. Nevertheless it represents only an extreme of variation in a population that is essentially *P. dorsalis*.

In life all these salamanders displayed brassy flecks on the dorsum, a character previously reported for several other species of the genus but not, apparently, for the present one.

Hemidactylium scutatum.—Martof (*op. cit.*: 167) reported one specimen from Oglethorpe County, and stated that the only other Georgia record was for the vicinity of Augusta, Richmond County. This is not the case. Bishop (*op. cit.*: 307) indicated the presence of the species over a sizeable area in eastern Georgia. Some years ago Dr. Bishop wrote me that this was done on the basis of specimens from, or published records for, Hart, Elbert, Oglethorpe, and Wilkes counties. The species was included in a 1940 list of Clarke County amphibians and reptiles (to which subsequent reference will be made). Grobman (1954, Fla. State Mus., Rept. Director, 1953–54: 11) recorded the species from the Jim Woodruff Dam area of Decatur County; his locality is about a mile north of the Florida line There is a record for Richmond County (Neill, 1948, Herpetologica 4: 107), other than the one mentioned by Martof. A Liberty County record (Cope, *op. cit.*: 132) is in error; the specimens (USNM 4090) are newts (*Diemictylus* species). *H. scutatum* has been collected in, but not reported from, Jackson County.

Stereochilus marginatus. — Like *Ambystoma mabeei*, this salamander has been included in the Georgia list on the strength of one old record for Liberty County. As mentioned previously, the early Liberty County records must be discounted when not supported by later finds. So far as I know, *S. marginatus* has not been rediscovered in the state; the nearest records lie about 135 miles to the northeast, in Berkeley County, South Carolina. Probably the species should be deleted from the Georgia list. Unfortunately, the single "Liberty County" example is the holotype.

Eurycea bislineata wilderae.—The status of this subspecies in Georgia needs clarification. Dunn (1926, The Salamanders of the Family Plethodontidae: 313) gave the range of *E. b. wilderae* as extending into the mountains of northeastern Georgia; he had a few specimens from Rabun and Gilmer counties. Mittleman (1949, Proc. Biol. Soc. Wash., 62: 91) mentioned two more Rabun County examples. A specimen (Mus. Zool. Univ. Mich., 76331) from 18 miles north of Cleveland, White County, also appears to be of this subspecies. In October, 1954, my wife and I collected salamanders in northwestern Georgia. At Chatsworth, Murray County, near the eastern edge of the Appalachian Valley, we secured 5 salamanders which were very close to *E. b. cirrigera*. About 34 miles to the southwest, at Kar-Tah Dell, Chattooga County, near the western edge of the Valley, we collected 12 salamanders clearly referable to *E. b. wilderae*. These *wilderae* were found beneath stones in a clear, swift, rock-bottomed brook; the local topography was rugged and the vegetation of upland affinities. In contrast, the *cirrigera* from Murray County were taken beneath logs and rocks along a fair-sized and somewhat turbid creek; the general appearance of the area was reminiscent of the Piedmont rather than the mountains. Thus, in northwestern Georgia two populations of *E. bislineata* may interpenetrate, separated ecologically.

Eurycea lucifuga.—Martof and Humphries (*op. cit.*: 247) reported this salamander from Dade and Polk counties. The species had previously been placed on the Georgia list (Neill, *op. cit.*: 2), and its presence in Dade County had been discussed

(Neill, *op. cit.*: 80). An older record also merits consideration. Cope (*op. cit.*: 168–170) did not distinguish *E. lucifuga* from *E. longicauda*, and lumped the two under the name "*Spelerpes longicaudus*." One of his *S. longicaudus* (USNM 8803) actually is *E. lucifuga*. Cope gave its provenience as Augusta, Georgia (Richmond County). Dunn (1926, *op. cit.*: 339) suggested that this locality was erroneous, and in truth the species is not likely to occur at Augusta. However, in 1953, While examining Georgia material in the U. S. National Museum, I noted that the actual datum was "near Demorest, Habersham County." This locality is about 70 miles outside the previously known range of the species. The Demorest area is of moderately high elevation, with a number of caves; it appears ecologically suitable for *E. lucifuga*. There are apparently isolated populations of this species far to the west of its continuous range (Bishop, *op. cit.*: 432), and I have long felt that there should be similarly isolated populations to the east, around the periphery of the Appalachian Mountains. While Cope's record cannot be accepted at face value, it is of sufficient interest to merit further search for the species in the Demorest vicinity.

Gyrinophilus danielsi dunni.—Martof (*op. cit.*: 167) reported this species at Athens, Clarke County, stating that his was the southernmost record. This is incorrect. It is known from Stone Mountain and Atlanta, De Kalb County, both localities more southerly than Athens (Neill, 1941, COPEIA (3) : 177, as *G. porphyriticus danielsi*; 1947, COPEIA (4) : 271). The southernmost acceptable locality is Lincoln County (Dunn, 1926, op. cit.: 271). There is no reason to doubt Dunn's record, for suitable habitats occur in the area, and the species ranges southward to the Fall Line in nearby South Carolina. A record for Liberty County (Cope, *op. cit.*: 157, as *G. porphyriticus*) is ecologically improbable.

Pseudotriton ruber schencki.—Three adult specimens (ERA-WTN 15654) from Kar-Tah Dell, Chattooga County, appear referable to this subspecies. The ground color is clear coral red above; the dorsal black spots are discrete; the venter is immaculate; the edge of the lower jaw displays a black bar. An example (USNM 76321) from Chatsworth, Murray County, also seems to be of this subspecies. Previous Georgia records are from the northeastern portion of the state. It may be mentioned that northwestern Georgia is almost unknown herpetologically; other interesting finds will doubtless be made in this area.

Scaphiopus holbrooki.—Martof (*op. cit.*: 169) stated that he had been unable to find the eastern spadefoot above the Fall Line in Georgia, and so felt that it did not occur outside the Coastal Plain in that state. I included the species in the aforementioned Clarke County list (1940) but did so following most other authors who considered the species to be virtually statewide in Georgia; I never saw a Clarke County specimen. However, the species has been reported from the Piedmont portion of Richmond County (Neill, 1951, Amer. Midland Nat., 45 (1) : 244). I have also collected it in the Piedmont portions of Hancock, Warren, McDuffie, and Columbia counties, and in Lincoln County which lies wholly outside the Coastal Plain. Piedmont examples are extremely large and blackish; there may well be an undescribed upland race.

Hyla gratiosa.—Martof (1954, COPEIA (2) : 157) reported one specimen of this frog from Dade County. He stated that all previous records, Georgia or otherwise, were from the Coastal Plain, except that for Hartselle, Alabama, "located in the Piedmont Plateau in the north central part of the state." The Piedmont does not extend into north-central Alabama; Hartselle is in the Appalachian Plateau, not the Piedmont; and the species has been reported from several localities outside the Coastal Plain. Burt (1938, Trans, Kansas Acad. Sci., 41: 347) recorded it from Lexington, Lexington County, South Carolina, just above the Fall Line; and from McCormick, McCormick County, South Carolina, in the Piedmont about 35 miles above the Fall Line. There is no reason to doubt these records, which were based on specimens collected by Dr. Burt himself. I have mentioned the presence of the species in the Piedmont portion of Richmond County (1951, *op. cit.*: 244), and have also taken it in the Savannah drainage as far north as northern Columbia County.

Martof concluded that "the population [of *Hyla gratiosa* in Dade County] does not appear to be genetically distinct from that of the Coastal Plain." It is not possible to determine the genetic distinctiveness of a population, or even its presence, from only one specimen.

Pseudacris brachyphona.—Martof and Humphries (*op. cit.*: 247) reported this species in northern Georgia, and stated that their records were the only ones for this state and the only ones east or south of the "Ridge and Valley Province." This is not precisely the case. *P. brachyphona* was once thought of as an upland species, but in recent years it has been collected at scattered localities on the Piedmont and the Gulf Coastal Plain. Chermock (1952, Geol. Surv. Alabama, Mus. Pap. No. 33: 35) gave its Alabama range as "south to the Black Belt," and this was done on the basis of actual specimens. (The Black Belt lies in the middle portion of the Coastal Plain.) A record of "*Pseudacris feriarum*" from the Apalachicola River drainage of Florida (Carr, 1940, Univ. Fla. Pub., Biol. Sci. Ser., 3 (1) : 56–57) is based on a perhaps subspecifically distinct population of this species, as I have remarked elsewhere (1954: 83). The southern-

most specimens, from Okaloosa County, Florida (*idem*), were shown to Dr. Archie F. Carr, who thought they were identical with his 1940 "*feriarum*." These specimens, seven in number, were compared with large series of *P. brachyphona* from the Tuscaloosa, Alabama, area (in the University of Alabama collection). The Florida examples and the Alabama ones are of the same species, in my opinion.

I have examined specimens of *Pseudacris brachyphona* from Athens, Clarke County; near Albany, Dougherty County; the North Georgia mountains; and the Gulf Coastal Plain of Alabama and Florida.

I should like now to discuss the amphibian fauna of two general regions in Georgia. First is the Athens area—Clarke and five bordering counties according to Martof's (1955) definition. Martof's paper purported to be an account of the amphibians known from this region. Martof admitted that much collecting had been done by others in the vicinity of Athens, but claimed that few data had been published. He avoided reference to the previous publications that do exist. As these would increase the usefulness and accuracy of his paper, I remedy the omission here.

During the latter 1930's and early 1940's, a great deal of herpetological collecting was done in the Athens area, by a number of individuals. The material thus secured formed the basis for a mimeographed account of, and key to, the herpetofauna of Clarke County. These were written in 1940, although undated. The key, used in the University of Georgia Zoology Department, was re-mimeographed in later years; whether it was altered in the process I do not know. The combined list and key may be cited as Neill (1940, Key to the Amphibians and Reptiles of Clarke County). This paper included all the species listed by Martof except *Gyrinophilus danielsi dunni*, *Desmognathus quadramaculatus* (introduced), *Cryptobranchus a. alleganiensis* (possibly introduced *fide* Martof), and *Ambystoma t. tigrinum* (probably introduced).

Martof has omitted several forms from his list. One of these is *Acris g. gryllus*, which occurs in the Athens area along with *A. g. crepitans*. (The respective ranges of these two frogs overlap in Georgia by at least 250 miles, without evidence of interbreeding; see Neill, 1950, Amer. Midland Nat., 43 (1) : 152–156; 1954: 81–82.) Its presence there was first noted by Bushnell, Bushnell and Parker (1939, Jour. Tenn. Acad. Sci., 14: 209). This record was surely not based on misidentified *A. g. crepitans*, for these authors specifically mentioned that the two frogs could be distinguished by markings, snout shape, and call. Later I reported *A. g. gryllus* from Clarke County (1950: 152).

Martof mentioned that some of his "*Desmognathus f. fuscus*" were darkly mottled, closely approximating *D. f. auriculatus*. As shown by Grobman (1950, Nat. Hist. Misc. No. 70), *D. f. auriculatus* is a blackish salamander entering Georgia only in the extreme lower Coastal Plain; the dull brownish *D. fuscus* of the upper Coastal Plain and lower Piedmont, often miscalled *auriculatus*, actually are *brimleyorum*. Grobman's spot map shows at least three localities for *brimleyorum* in or near Clarke County. The subspecies is common in the valley of Dry Fork Creek, the eastern border of Martof's Athens area.

The presence of *Pseudacris brachyphona* near Athens has been mentioned. We found it only once, between Athens and Princeton, when it advertised its presence by a quacking call unlike that of *P. nigrita feriarum* which was also calling.

Martof included *Ambystoma t. tigrinum* on the basis of one larva from Whitehall, Oconee County. If the identification is correct, the record may rest on an introduction. About 1939, O. K. Fletcher, Jr. was interested in the utilization of *Ambystoma* eggs, larvae and adults. On many occasions he transplanted tiger salamander egg masses and larvae from the Coastal Plain to pools of the Athens area. Whether the species was stocked at Whitehall I do not recall; but this locality was a favorite one with Athens collectors at that time. Reliable Georgia records of *A. t. tigrinum* are all from the Coastal Plain, so far as I know. Efforts were also made to stock other Coastal Plain ambystomids around Athens.

Martof stated that slimy salamanders, *Plethodon g. glutinosus*, 30 to 40 mm. in total length, were taken in March, "presumably the month when transformation occurs." Of course, slimy salamanders, having no aquatic larval stage, do not transform. In the Georgia Piedmont, newly hatched *P. glutinosus* are encountered as early as latter December. Also, it may be noticed in passing that the green frogs of the Athens area are of the subspecies *Rana clamitans melanota* (Mecham, 1954, Texas Jour. Sci., 6 (1) : 1–24); and that *Rana palustris* is now known to range southward to the Fall Line in Georgia, having been taken in Oglethorpe and Richmond counties.

The Athens area, as defined by Martof, is not homogeneous. Its eastern edge, the valley of Dry Fork Creek and Broad River in Oglethorpe County, is quite unlike the surrounding Piedmont (see Neill, 1947, Herpetologica, 3: 205). Although about 75 to 100 miles above the Fall Line, it is relatively low and flat; the creek is comparatively slow, silt-bottomed and meandering. The valley is one of the few localities for the relict oak, *Quercus oglethorpensis* Duncan. Its dusky salamanders are *Desmognathus fuscus brimleyorum*, whereas *D. f. fuscus* inhabits most of the surrounding region. A series of spring peepers from this locality exhibited the characters

of *Hyla crucifer bartramiana*, supposedly a Coastal Plain form. The single banded water snake that I collected in Dry Fork Creek appeared to be of the Coastal Plain subspecies, *Natrix sipedon fasciata*, while *N. s. pleuralis* occurs in other streams of the area. As noted previously (*idem*), the valley harbors an isolated population of the cottonmouth, *Agkistrodon piscivorus*, the only such population in the Piedmont.

Richmond County may now be considered. In a study of reptile and amphibian hibernation, I presented a checklist for this county (1948, Herpetologica, 4: 107–114). *Ambystoma texanum* was included on the basis of one specimen which I now think was introduced, perhaps in the balled roots of shrubs (Neill, 1954, *op. cit.*: 78). The species should be excluded from the county (and state) list. My specimens of "*Desmognathus fuscus auriculatus*" are now to be called *D. f. brimleyorum* following Grobman (1950, *op. cit.*). Since the list was prepared, three races of *Plethodon glutinosus* have been recognized in the Southeast: *P. g. grobmani* in Florida and South Georgia, *P. g. chlorobryonis* in the Carolina Coastal Plain, and *P. g. glutinosus* farther north. The Richmond County population, a blend of all three, is perhaps closest to *chlorobryonis*. Similar examples from nearby South Carolina have been called *chlorobryonis* by Freeman (1955, Univ. S. C. Pubs., Biol. Ser. 3, 1 : 227–238), who credited the identification to Dr. Albert Schwartz. The subspecies *P. g. chlorobryonis* may thus be added to the Richmond County (and Georgia) list. Populations of *Pseudotriton montanus* from the northern part of Richmond County are essentially *P. m. montanus* (Neill, 1948, Copeia (2) : 134–136), which should be added to the county list. Both *Rana c. clamitans* and *R. c. melanota* occur, the former in the Coastal Plain portion of the county and the latter in the Piedmont. Two localities for *Rana palustris* have been found near Augusta. Francis L. Rose discovered a large, dark gopher frog, perhaps closest to what is now called *Rana capito sevosa* but representing a distinct subspecies. This novelty was reported on by William E. Brode and myself in a talk, "Frogs of the *Rana areolata* Group in the Southeastern United States," given at the 1955 meeting of the ASIH, Southeastern Division, at Highlands, North Carolina. Further studies will be forthcoming.

Richmond County is roughly triangular, its sides respectively 23, 25 and 33 miles in length. It harbors populations of 20 salamanders, 27 frogs, one crocodilian, 11 lizards, 36 snakes and 13 turtles, so far as is known. The total of 108 forms (counting subspecies separately) is extremely large for so small an area. Several other species have been taken within a few miles of the county, and are to be expected therein.—Wilfred T. Neill, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida.*

A COMPARISON OF LIVING *PLETHODON OUACHITAE* AND *P. CADDOENSIS*.—Comparison of living *Plethodon ouachitae* and *P. caddoensis* was made possible when 12 *ouachitae* were collected the night of April 22, 1955, at Howard, Arkansas, and 14 *caddoensis* the next night at Albert Pike Camp, 15 miles southwest of Norman, Arkansas.

The eight largest specimens of *ouachitae* average 52 mm. (range 50–56) in snout-vent length, as compared with 44 mm. (range 42–47) for the eight largest *caddoensis*.

Costal groove counts show no difference between *ouachitae* and *caddoensis*, 16 costal grooves being found in all specimens of both species. Likewise, the number of intercostal folds between appressed limbs does not differ in the two species (all 12 specimens of *ouachitae* and 11 of 13 *caddoensis* have appressed limbs separated by less than one intercostal fold).

Five of the 12 specimens of *ouachitae* have some chocolate brown dorsal color whereas none of the *caddoensis* shows such color. Of the 9 largest *ouachitae*, 6 have the terminal one-third of the tail without light dots in dorsal aspect, one has 1 dot, and 2 have 2 dots. All the 10 largest *caddoensis* have the terminal one-third of the tail dotted (av. 16.1 dots, range 8–30). The venter is more spotted in *caddoensis* than in *ouachitae*. As to number of spots, *ouachitae* were classified: none—1, few—8, moderate—3. On the other hand, *caddoensis* were as follows: few—2, moderate—9, profuse—3. The pectoral area is lighter than the post-pectoral area in 12 of 14 *caddoensis* as compared with 2 of 12 *ouachitae*. As to amount of light dorsal pigmentation, the dorsum was classified as more than 50 percent light in 10 of 14 *caddoensis*, as compared with 5 of 12 *ouachitae* (the light pigment is more bronze in *ouachitae*, more nearly white in *caddoensis*).

April 30, 1955, Mr. James Jones collected four salamanders on the south side of Poteau Mountain near Oliver, Arkansas. Two of these came into my possession while still alive. They resemble *caddoensis* in markings of the tail tip and pectoral area. In ventral markings one is more *caddoensis*-like, the other *ouachitae*-like. There is no chocolate brown on the back, but the many small chromatophores are bronze, as in *ouachitae*.

There is no question but that the population of salamanders at Albert Pike Camp (Cossatot Mountains) is genetically distinct and easily separable from the Howard (Rich Mountain) population. It seems possible that isolation and genetic drift may have developed a number of more or less discrete populations in this area. How much re-

productive isolation has been achieved, and what the taxonomic treatment of these forms should be, remains to be discovered.—ALBERT P. BLAIR, *Department of Zoology, University of Tulsa, Tulsa, Oklahoma.*

OBSERVATIONS ON THE EGGS AND YOUNG OF *PLETHODON RICHMONDI*.—Wood (1945, Herpetologica, (2) : 206–10) stated that *Plethodon richmondi* probably deposits its eggs in May, and Duellmann (1954, COPEIA, (1) : 40–45) concurred, but mentioned eggs, presumably of this species, found on July 14.

On August 23, 1955, two adults, two eggs, and two newly hatched young of *Plethodon richmondi* were found about ten inches below the surface of the ground beneath a flat stone about ½ mile southwest of Maysville, Mason county, Kentucky. The stone was imbedded horizontally in the steep side of a hill about four feet above a small dry stream bed. One of the adults escaped into a crevice in the ground, and the other, a female, was collected. Apparently the two young salamanders had been hatched recently, because the two remaining eggs ruptured when touched, and the emerging young were indistinguishable from the other two. All of them were capable of effective locomotion. The adult female had a regenerated tail; her snout-vent length was 46 mm., and she had 21 costal grooves. She contained four ovarian eggs, each 1 mm. in diameter.

In general appearance the hatchlings were light gray above, with an immaculate belly. The eyes and eyelids were black and conspicuous. The dorsal coloration consisted of a large number of small round white spots in a network of black. The network was less dense on the dorsal surface of the legs than elsewhere, and became progressively reduced on the sides toward the belly. It completely covered the tail with the exception of a narrow mid-ventral line that was uniformly gray, somewhat darker than the belly. The hatchlings were almost identical in size; three of them had a snout-vent length of 14 mm., the fourth 15 mm. The tail length of each was 8.5 mm.

The locality where the specimens were taken is characterized by numerous limestone outcroppings and is wooded with deciduous trees. At the time the collections were made the area was quite dry, although well shaded. During early spring many individuals of *Plethodon richmondi* may be found under stones and logs, but they are much more difficult to find later in the year. Those discussed above were the only ones found during a day of collecting in the area. They are deposited in the zoological collection of the University of Kentucky.—JAMES T. WALLACE AND ROGER W. BARBOUR, *Department of Zoology, University of Kentucky, Lexington.*

A GARTER SNAKE "BALL".—In April, 1955, I encountered the second "snake ball" I have seen at Seymour, Connecticut. While walking along Cherry Street near a steep embankment I heard some rustling in the leaves near the road and saw several snakes writhing on some leaves in the sun. I watched the snakes at a distance of 7 or 8 feet, yet they seemed to be undisturbed by my presence. There were three snakes fairly closely grouped but in the next few minutes three of four more snakes joined them. At first there seemed to be no organization to their activities but in a short while they aligned their bodies and entangled their tails. Several times they became so engrossed in their activities that the whole group rolled for a foot or two down the bank toward the road.

After about ten or fifteen minutes of rather vigorous activity, during which they were tightly massed together, several of the snakes wandered off. Several others left the group but then returned. One snake (it seemed to be the largest of the group), was apparently at the center of activity.

About twenty minutes after I first came upon the snakes, and after several of them had left the group of their own volition, I moved to them and all but two left. These lay still with only their tails moving slightly and neither attempted to escape or defend itself. Upon picking them up, I found they were copulating. When I put them back on the ground the larger one (presumably the female) crawled off, dragging the other snake with her. Both were passive and did not seem to be disturbed by handling.—J. B. GARDNER, *20 First Avenue, Seymour, Connecticut.*

EGGS AND YOUNG OF THE PRAIRIE KING SNAKE, *LAMPROPELTIS C. CALLIGASTER*.—Two gravid prairie king snakes were collected on May 29 and June 5, 1954, five miles northeast of Carbondale, in Jackson County, Illinois. On the night of June 19 or early the following morning, the larger individual (total length 1000 mm.) deposited 11 eggs. The other female (900 mm.) laid eight eggs on the afternoon and evening of June 27, at intervals of 12 to 24 minutes, except for the last egg, which was deposited at least four hours after its predecessor. These observations agree essentially with those reported by Clark (1954, Herpetologica, 10: 15–16).

The day following deposition the eggs were weighed, measured, and numbered for future identification. The lengths of the 11 eggs produced by the larger female varied from 34 mm. to 43 mm., average 37.9 mm.; diameters ranged from 19 mm. to 22 mm., average 21.1 mm. The mean weight was

10.72 grams with a range of 10.0 gms. to 11.4 gms. The lengths of the eggs produced by the smaller female varied from 38 mm. to 46 mm., average 40.0 mm. Diameters ranged from 17 mm. to 19 mm., average 18.0 mm. Weights ranged from 8.2 gms. to 9.6 gms., average 8.93 gms.

The eggs were incubated on a substrate of damp cotton and paper towels in covered glass containers. Temperatures, approximating those of the outdoors, varied from 60° to 110°F. with a mean of about 85°F. An egg of the first clutch opened on July 29 contained a well developed embryo. Three young emerged from this clutch on August 3, and six the following day. One unhatched egg, opened August 8, contained a dead abnormal embryo with a markedly malformed vertebral column, abnormally small eyes, and a much enlarged lower jaw. Of the other clutch, four eggs hatched on August 15 and three the following day. The last egg laid became badly desiccated soon after deposition and was discarded.

The incubation periods were 45 and 49 days. Newly hatched prairie king snakes were noted in the area where the adults were taken shortly after the eggs hatched in the laboratory.

From one to six slits appeared in the top of each egg prior to the emergence of the young. One individual experienced difficulty in making its exit from the egg because the slit was too small. The hatchlings were docile upon leaving the eggs, but in two or three days they became irritable and aggressive. The egg tooth was lost after two to three days and the first ecdysis occurred after 8 to 11 days.

The number of dorsal blotches in the entire series of hatchlings varied from 40 to 48 with a mean of 44.2. Two individuals in the first group of young exhibited a variation in pattern in which all but four of the dorsal blotches were divided medially to produce a striped appearance.

The mean total length of the individuals in the initial brood was 260.5 mm. (249.0 mm. to 271.0 mm.). That of those in the second group was 265.4 mm. (250.0 mm. to 277.0 mm.). Tail lengths varied from 28 mm. to 37 mm. and 32 mm. to 39 mm. with averages of 33.4 mm. and 33.5 mm., respectively, and constituted an over-all average of 12.7 per cent of the total length. The average weights (in grams), 9.05 (7.7 to 10.1) for the first group and 7.45 (6.9 to 8.0) for the second, provided the most marked difference between the two groups of hatchlings.

Representative specimens were preserved and placed in the author's private collection.

I wish to acknowledge the aid of Dr. James N. Layne, Assistant Professor of Biology, University of Florida, and Dr. Willard D. Klimstra, Director, Wildlife Research Laboratory and Associate Professor of Zoology, Southern Illinois University, who criticized and helped with this paper.—C. ROBERT SHOOP, *Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Illinois.*

NOTES ON A DORMANT PILOT BLACK SNAKE.—On December 11, 1954, a dormant pilot black snake, *Elaphe o. obsoleta* (Say), judged to be about five feet long, was discovered within a crevice in a limestone bluff bordering the Mississippi River floodplain two miles southeast of Aldridge, Union County, Illinois. The bluff was about 50 feet high, had a western exposure, and overlooked an extensive tract of lowland woods. The snake was some 30 feet above the general ground level in a deep fissure that extended vertically from a narrow, high recess near the base of the bluff to the top. It was loosely coiled in a vertical position and wedged into a narrow part of the fissure about 1½ inches wide at a point about 2 feet above the top of the recess and 6 or 7 feet from the face of the bluff. The snake was partly visible from the ground and could be approached within a few feet by climbing to the recess and back into the cliff.

When examined on December 18, the dormant snake had moved a few inches downward and about 2 feet deeper into the fissure, where its body was supported below by a shelf of rubble. Air temperature near the bluff was 36°F. Despite the relatively exposed nature of the hibernaculum, the temperature within a few inches of the snake was 48°. Torpor was not complete, for the snake instantly inflated its body when lightly touched with a stick.

The outside temperature had dropped to 29° on the following day, yet a temperature of 45° was recorded within the crevice a few inches from the snake, which was still in the same position except that its head was raised. No perceptible respiratory movements were noted during three minutes of close observation. The snake responded to a touch as on the previous visit and slowly extended and retracted its tongue and made slight head movements after being illuminated with a powerful flashlight for several minutes.

The site was abandoned between December 19 and 28. On the latter date, the fissure that had been occupied by the snake was dripping with water as the result of recent rains. Day-time temperatures had reached 60° in the preceding week. Probably either the excessive moisture in the hibernation site or the stimulus of warm weather, or both, had caused the snake to become temporarily active and leave its retreat.—JAMES N. LAYNE, *Department of Biology, University of Florida, Gainesville, Florida.*

A NOTE ON THE FEEDING HABITS OF THE CUBAN RACER, *ALSOPHIS ANGULIFER* (BIBRON).—Allen, in his comprehensive

study of bats, (1939, Bats) makes no mention of the genus *Alsophis* in his discussion of bat-eating snakes.

On December 22, 1954 a Cuban racer, *Alsophis angulifer* (Bibron), was captured at a cave near Trinidad, Las Villas Province, Cuba. During capture it regurgitated a fruit eating bat, *Phyllonycteris poeyi*, a large colony of which inhabited the cave. The snake was taken at approximately 8:00 PM just after the bats had emerged for the evening. It was found crossing the steep slope of the cave entrance.

A second racer was captured on September 13, 1955 at the same cave. The stomach of this individual contained two bats, both *Phyllonycteris poeyi*. This snake, like the first, was captured at the cave entrance just after the emergence of the bats.

The cave is located seven miles west of Trinidad on the east side of the Guanayaro River approximately one mile north of the coast. It is situated on a rugged limestone ridge.

A word of appreciation is due Dr. David H. Johnson of the United States National Museum, for his identification of the bat skulls.—JERRY D. HARDY, JR., *Department of Zoology, University of Maryland, College Park, Maryland.*

LONGEVITY OF SNAKES IN CAPTIVITY IN THE UNITED STATES AS OF JANUARY 1, 1956.—Following the practice established by the late C. B. Perkins, it is intended to continue the annual publication of longevity records of captive snakes in the United States. Departure from the established form is being made, however. Henceforth, the tabulation will contain only records of snakes still living plus those that have died during the previous year. Those interested in the most recent complete list of snakes living ten years or more in United States collections are referred to Perkins' final report (1955, COPEIA, (3) : 262).

The list will be brought up to date each year as of the first of January. Only the oldest snake of each species or subspecies will be listed. We would appreciate hearing from anyone having better records, or ten-year records of other species. The age is given in years (second column) and months (third column), and the source of the record is included (fourth column). An asterisk indicates that the individual was alive on January 1, 1956. Symbols used are as follows: BdZ = Brookfield Zoo, GPM = George P. Meade, JGM = John G. Moore, PZ = Philadelphia Zoo, RMS = R. M. Stabler, SDZ = San Diego Zoo.

*Agkistrodon contortrix laticinctus**	15	7	SDZ
Agkistrodon contortrix mokeson	19	0	SDZ
*Boa constrictor imperator**	18	2	SDZ
*Crotalus atrox**	19	7	SDZ
*Crotalus ruber ruber**	14	4	SDZ
Crotalus tortugensis	18	4	SDZ
*Crotalus viridis helleri**	18	10	SDZ
*Crotalus viridis viridis**	17	1	SDZ
*Drymarchon corais couperi**	23	4	JGM
Elaphe obsoleta quadrivittata	17	11	SDZ
Elaphe obsoleta spiloides	13	11	RMS
*Epicrates angulifer**	17	2	SDZ
*Lampropeltis doliata amaura**	19	7	GPM
*Lampropeltis doliata annulata**	15	4	SDZ
*Lampropeltis doliata triangulum**	10	9	PZ
Lampropeltis getulus floridana	12	2	SDZ
*Lampropeltis getulus holbrooki**	12	8	SDZ
*Loxocemus bicolor**	13	0	PZ
*Naja melanoleuca**	27	3	SDZ
*Naja nigricollis**	21	2	BdZ
Pituophis catenifer annectens (albino)*	15	7	SDZ
*Pituophis melanoleucus melanoleucus**	15	5	SDZ
*Python curtus curtus**	19	10	SDZ
*Python molurus bivittatus**	19	9	SDZ
*Python regius**	10	9	PZ
*Python sebae**	19	1	PZ
*Rhinocheilus lecontei lecontei**	14	1	SDZ

CHARLES E. SHAW, *Zoological Society of San Diego, San Diego, California.*

ALGAL OCCURRENCE ON THE TURTLE *CLEMMYS GUTTATA*.—Although the spotted turtle, *Clemmys guttata*, is a strongly aquatic species, epizoization has been noted previously only on captives (Neill and Allen, 1954, Ecology, 35(4) : 581). The algal epizoic involved was not determined. *Clemmys guttata* can now be added to the list of North American fresh-water turtles epizoized in the natural state.

On April 9, 1955, the writer collected two adult male spotted turtles in a pond adjacent to Pond Hill Road in North Haven, Connecticut, each of which had algal growth on its carapace. The pond is roughly circular and approximately 120 feet in diameter, with the major portion of its area dominated by sedge hummocks (*Carex*), and with young red maples (*Acer rubrum*) scattered irregularly throughout the hummocks. The pond's surface is covered with floating-leafed aquatic plants and its bottom is muddy. A grove of maple borders the south side and a meadow, dotted with red cedar (*Juniperus virginiana*), is on the west and north. Pond Hill Road runs along the eastern periphery.

Examination of the specimens revealed two genera of algae on the shells. On the larger specimen (carapace length 105 mm.) the rare *Dermatophyton radicans* Peters was evenly distributed posteriorly on the shell, extending from lateral 3 to central 5, and laterally to marginal 7. This chaetophoralean has been found twice before on a turtle (Edgren,

Edgren and Tiffany, 1953, Ecology, 34(4) : 733). Four other spotted turtles captured at the same time also exhibited *Dermatophyton* colonizations. The carapace of the smaller turtle (length 89 mm.) had a sparse algal growth of *Cladophora Kuetzingiana* Grunow restricted to the left side, and extending from laterals 3 and 4 to marginals 9, 10, and 11. This alga has not been reported before as an epizoic on a turtle.

On May 20, 1955, seven more adult spotted turtles from this same pond were captured and examined for traces of epizoics. Three of four males had small amounts of *Cladophora Kuetzingiana* on the marginal laminae. Of the females, two lacked algae and the third had a small amount of the same alga on two marginals.

On May 25, 1955, two subadult males (carapace lengths, 75 mm. and 83 mm.) collected at the pond had small amounts of *Cladophora Kuetzingiana* limited to several marginal laminae.

Random samples from several other *Clemmys* populations in south-central Connecticut, collected during the summer of 1955, failed to bring to light any epizoization. However, on May 19, 1956, two adult male spotted turtles were collected at different localities, each of which had a growth of *Dermatophyton radicans* on the carapace. The first specimen was captured in a meadow stream at a distance of 500 yards from the Pond Hill Road pond. The stream does not empty into the pond. The second turtle was collected from another meadow stream in Wallingford, Connecticut.

The writer wishes to thank both Prof. G. W. Prescott, Michigan State University, and Prof. Richard D. Wood, University of Rhode Island, for their determinations of the algae.—HENRY C. MOSKI, *Peabody Museum of Natural History, Yale University, New Haven, Connecticut.*

NON-SWIMMING WATER TURTLES IN IRAQ.—Aquatic turtles are swimming turtles, and it would seem that a record of non-swimmers is unique. The following observation was made on Oct. 12, 1954, while I was a member of the Iraq-Jarmo Archeological Expedition of the University of Chicago.

The turtle population in question occurred in a spring and short stream at the base of the southern flank of the Safin Dagh (Safin Mountain), in Erbil Liwa, northern Iraq, near the village of Khorkawa. The Safin Dagh is the lowest of several successive limestone anticlinal mountains forming the southern border of the Zagros Mountains in Iraqi Kurdistan; small springs emerge from the base of the mountain and run toward the Bastura River, a tributary of the Greater Zab. Both the Bastura and the small tributaries running into it from the numerous springs are dry from mid-spring into late autumn or early winter, since the rainfall (approximately 10 inches per year) is mostly in the first four months of the year, and most of the available summer water is used for irrigation.

A group of us on archeological reconnaissance, sitting around one such spring at lunch-time, noticed that none of the turtles, *Clemmys caspica caspica* (Gmelin), was swimming at any time; each one would crawl up the muddy bank to the surface to breathe and then slide back down again. Thinking this behavior strange, I took one adult back to camp, placed it in a large bathtub, and added water until the turtle could no longer reach the surface, even when standing on its hind legs. After 10 minutes the animal started active explorations, and in another 10 minutes was acting in a manner I would describe as frantic. Due to the sloping sides and back of the tub it could stand erect only at the front, where it finally stationed itself with neck outstretched in an attempt to reach the surface. But seemingly the animal could not (or would not?) swim.

When the water was lowerd to a level such that the nostrils could barely penetrate the surface, the turtle breathed several times, a whistle marking each respiration. The animal would then retire to the bottom, to repeat the whole performance at 10–15 minute intervals, but under no circumstances could I get it to swim, although when trying to climb the slick sides of the tub it would paddle furiously.

It is possible that this non-swimming behavior has an adaptive value, in a semi-desert country where the main river of the area, the Bastura, is intermittent in its flow but often at flood when flowing. Turtles that stay at home in their small spring live to reproduce.

I had no other opportunity to study turtles in Iraq, but Dr. Charles Boswell of the Royal Medical School, Baghdad, tells me that this same turtle swims very well in the lower Tigris River, a permanent stream.

I am indebted to Hyman Marx, of the Chicago Natural History Museum, for identification of the turtle. My work with the Iraq-Jarmo Archeological Expedition was financed by a grant from the National Science Foundation to the Department of Anthropology of the University of Chicago.—CHARLES A. REED, *College of Pharmacy, University of Illinois, Chicago 12, Illinois.*

LATE PARTURITION IN THE RUBBER SNAKE.—A rubber snake, *Charina bottae*, captured in the Mission Creek drainage, Chelan County, Washington, on August 3, 1953 by State Game Protector Robert Leslie, gave birth to three young on or about October 5, 1953. It was housed in a locked case from which escape of young was

impossible. Two were found on the morning of October 5 with yolk stalks still fresh. The female (WSC 53-247) was killed for preservation on October 6 and a third young, partly digested, was found in the stomach. The uterus was empty. One juvenile (WSC 53-248) was preserved; total length 218 mm., tail 25 mm.

On November 25, 1954 George F. Hudson found a dead juvenile of this species on a railroad embankment at Parvin, Whitman County, Washington. The umbilicus was still bloody and I estimate that this specimen had been dead not more than two or three days.

The late November date of birth raises the question of winter survival. In a year with mild fall weather perhaps adequate food could be obtained before hibernation. Another possibility is that such individuals might survive the first winter without feeding, although there appears to be no evidence to support this.—GEORGE E. HUDSON, *Department of Zoology, State College of Washington, Pullman, Washington.*

AN ELECTRICAL SHOCKER FOR THE COLLECTION OF AMPHIBIANS AND REPTILES IN THE AQUATIC ENVIRONMENT.—Electrical shocking has become one of the most important means of collecting freshwater fish for experimental purposes. Several types of shockers have been devised. One of the most popular consists of a 230 volt, 180 cycle, alternating current, portable generator equipped either with electrodes mounted on a boat for lake work or hand electrodes for stream shocking. The present discussion is concerned with this type. Frogs, salamanders, snakes, and turtles are readily stunned. Unfortunately, however, they sink to the bottom with the exception of an occasional snake. Thus clear, shallow water is most easily sampled whereas the method is of little value in deep, turbid water.

In connection with the electrical stunning of reptiles, incidental to the collecting of fish, the question has often arisen as to whether or not stunned reptiles are drowned. In the laboratory when snakes and turtles were stunned and subjected to a continuous shock for a period of two minutes, they recovered in every instance. Recovery is so rapid that drowning probably does not occur.

After several years of experience in collecting fishes by electrical shock and observing the incidental stunning of amphibians and reptiles, the authors feel that the method offers new possibilities to those persons interested in the collection of these forms.—GERALD E. GUNNING AND WILLIAM M. LEWIS, *Cooperative Fisheries Laboratory, Southern Illinois University, Carbondale, Illinois.*

PARTIAL METAMORPHOSIS INDUCED IN *TYPHLOMOLGE RATHBUNI*.—The blind, unpigmented, aquatic cave salamander, *Typhlomolge rathbuni* Stejneger, has been reported to lack a thyroid gland or to possess, at most, only a few undifferentiated epithelial rudiments (Uhlenhuth, 1923, Biological Bull., 45:303-24). This fact led Uhlenhuth and others to speculate as to the relationship between the absence of a functional thyroid and the neotenic condition of this peculiar plethodontid salamander. Gorbman (1956, COPEIA, this issue) reports his findings on two specimens of *Typhlomolge* which "... contained well developed, though inactive-looking thyroids (about 100 follicles each)". Kezer (1952, COPEIA, 4:234–37) grouped the neotenes in four categories: (1) *Typhlomolge*, lacking a thyroid gland and untested with metamorphosing agents; (2) perennibranchs, such as *Necturus*, in which natural metamorphosis never occurs and attempts to induce metamorphosis experimentally produce little or no change, possibly due to the insensitivity of their tissues to the thyroid hormone; (3) various species of newts and ambystomid salamanders which may or may not undergo natural metamorphosis, depending on environmental conditions, but which are capable of experimental metamorphosis; and (4) certain plethodontid salamanders of the genus *Eurycea*, in which natural metamorphosis does not occur but which are easily induced to metamorphose with dilute solutions of thyroxin.

A single *Typhlomolge* was maintained under experimental conditions for approximately 54 days. This individual, an immature male with a snout-vent length of 33 mm. and a total length of 60 mm., was supplied through the courtesy of John E. Werler of the San Antonio Zoological Society, who obtained it in Hays County, Texas, only a few miles from the type locality.

The salamander was placed on arrival in a covered, opaque gallon jar containing a solution of racemic thyroxin crystals dissolved with a drop of 4 percent NaOH solution and diluted with distilled water. From January 25 until February 9, 1955 the animal remained in 500 ml. of 1:1,000,000 solution. It was then transferred to 500 ml. of a fresh 1:500,000 solution, which was renewed on February 17. By February 28 no metamorphic changes were detectable. These concentrations will usually produce marked metamorphic changes in *Eurycea* and *Typhlotriton*. The animal was then transferred to 500 ml. of 1:100,000 solution, while in a separate container several *Eurycea tynerensis* were maintained in the same concentration to check on the efficacy of the hormone. Throughout the experiments the animals were kept in a room with a temperature range of 19° to 23° C., a range which brackets the normal environmental temperatures of

Typhlomolge, but which does subject them to more than normal temperature variation. Occasionally *Daphnia* were provided as food.

Between March 1 and 19, the date the *Typhlomolge* died, a gradual atrophy of the labial folds, gills, and fins (all larval structures) was noted. The *Eurycea* treated similarly underwent a comparable change within 14 days. At the time of death only a remnant of the longest gill was left on each side of the *Typhlomolge* and the other two pairs of gills were reduced to heavily pigmented stubs. The slits remained open. The caudal and dorsal fins were completely reduced, as were the labial folds.

Following fixation, the animal was cleared in KOH and stained with alizarin. This technique revealed that the animal had developed maxillae and a beginning of maxillary dentition, and also a small ossification, possibly an unpaired septomaxilla. These characters are normally absent in untreated specimens. The treated specimen did not develop an os thyreoideum, but the structure is represented by a cartilaginous piece in an untreated male 74.5 mm. in total length and by an ossified pteriform structure in an untreated 105 mm. male.

A histological preparation of the skin shows only larval features.

Additional *Typhlomolge* were not available for controls but it seems unlikely that natural metamorphosis occurs. Uhlenhuth (op. cit.) maintained an individual for 14 months without change, and John Werler has kept specimens for periods of two years without change.

The evidence obtained suggests that *Typhlomolge* should be classified with the neotenic *Eurycea* as a species which demonstrates metamorphic changes in the presence of thyroxin although it may never metamorphose completely under either experimental or natural conditions. The neotenic condition of *Typhlomolge* is perhaps due in part to lack of an active thyroid gland or a lack of sufficient thyroid hormone, and not to a complete insensitivity of its tissues to thyroxin.

Appreciation is extended to E. R. Squibb and Sons who kindly supplied the thyroxin utilized in the experiments.—HAROLD A. DUNDEE, *Department of Zoology, University of Michigan, Ann Arbor, Michigan.*

Ichthyological Notes

THE SOUTHERN REDBELLY DACE, *CHROSOMUS ERYTHROGASTER ERYTHROGASTER*, FROM THE LOWER MISSISSIPPI RIVER DRAINAGE.—The range of this subspecies according to Eddy and Surber (1947, Northern Fishes: 155) is from Iowa through southern Wisconsin to Pennsylvania and southward to Alabama and Oklahoma. The following records extend its southern range to the lower Mississippi River drainage of Mississippi.

The Mississippi collections are mainly from a somewhat isolated population which seems to be concentrated at the base of a small waterfall in Bliss Creek, a tributary of the Yazoo River, 7 miles northeast of Vicksburg, Mississippi. Eleven specimens were collected on April 26, 1952, four on May 15, 1954, and thirty-six on March 12, 1955. The water was 2 to 3 feet deep, clear, and slow moving. The bottom was rocky with a small amount of silt. None of the above specimens was taken either above the waterfall or beyond a distance of thirty feet downstream from the base of the fall. Specimens collected on March 12, 1955, were brilliantly colored. Large numbers of *Campostoma anomalum* and *Semotilus atromaculatus* were found associated with the Redbelly Dace.—ANDREW FREDERICK HEMPHILL, *Department of Biology, University of Alabama, University, Alabama.*

THE OCCURRENCE OF THE SQUARETAIL, *TETRAGONURUS CUVIERI*, ON THE HIGH-SEAS SOUTH OF THE ALEUTIAN ISLANDS.—During the months of August and September, 1955, two fishing vessels, the PARAGON and MITKOF, were chartered by the Pacific Salmon Investigations, U. S. Fish and Wildlife Service, to conduct salmon studies in the North Pacific Ocean. One of the areas studied was bounded by Lat. 45–50°N. and Long. 165°W.–175°E. Each vessel was equipped with twelve shackles of gill-nets in varying mesh sizes of 5¼-inch mesh, 4½-inch mesh, 3¼-inch mesh and 2¼-inch mesh, stretched measure. Each shackle was approximately 300 feet long and 20 feet deep. These nets were set before dark and allowed to soak overnight on each fishing station.

An incidental catch of 146 squaretails was made on the 45°N. Lat. line, the majority being caught in the small 2¼-inch mesh gill-nets. The PARAGON had an unusually large catch of 127 in one set at

Long. 177°30′ E. The MITKOF caught 13 in a set at Long. 167°35′ W. and six more at Lat. 44°50′ N., Long. 170°03′ W. The surface water temperature was 19.1°C. on the PARAGON's set and 16.2°C. on both sets of the MITKOF.

Previous literature cites the occurrence of *T. cuvieri* in temperate seas from various parts of the world. Grey (1955, Carlsberg Found. Oceanogr. Exped. Round the World 1928–30, Dana Rept., No. 41) in a monographic treatment of the genus *Tetragonurus* cites records of *T. cuvieri* in the North Pacific Ocean off California, Japan and the Hawaiian Islands and north to about 32°N., 173°W. Previously, Welander and Alverson (1954, Wash. State Dept. Fish., Fish. Res. Papers, 1(2) : 37–44) recorded the landing of *T. cuvieri* from off Vancouver Island as the first from waters north of California.

The squaretails taken by the two charter vessels are the first record of this fish from the high seas of the North Pacific north of the 40°N. Latitude line, and in such great numbers from one locale. This adds to the supposition of Fitch (1951, California Fish and Game, 37(1) : 55–59) that this fish is much more common than past records indicate. It also adds to the suggestion by Grey (1955, *op. cit.*) that *Tetragonurus* is a widespread, gregarious fish. Previous literature, as discussed by Grey (1955, *op. cit.*), suggests that the squaretail may exhibit diurnal vertical migration. The presence of these fish in the surface waters at night is indicated by the nature of their capture by the two vessels.

The majority of the fish taken were more than 250 mm. in total length. One specimen from the PARAGON was placed in formalin. Two specimens from the MITKOF's catch were frozen immediately upon capture and preserved in formalin a month later. These maintained their uniform dark brown color throughout their frozen state and have subsequently been placed in the Chicago Natural History Museum collection.—GEORGE K. TANONAKA, *Pacific Salmon Investigations, U. S. Fish and Wildlife Service, Seattle, Washington.*

RECORDS OF THE LAMPREY *LAMPETRA AEPYPTERA* FROM ALABAMA—*Lampetra aepyptera* (Abbott) has previously been reported only twice from rivers draining into the Gulf of Mexico. These are the Alabama River system near Rome, Georgia (Raney, 1952, COPEIA(2) : 98–99) and the Tombigbee and Pascagoula drainages, Mississippi (Cook, 1952, COPEIA(4) : 268). Although Raney points out the possible widespread occurrence of this species, there is apparently no previous record from Alabama.

The Alabama collections consist of one adult male collected on March 10, 1951, from Jay Creek, a tributary of the Black Warrior River; ten adult males and twelve adult females collected on March 22, 1956, from Hurricane Creek, a tributary of the Black Warrior River; three ammocoetes collected on June 8, 1956, from Hurricane Creek; and seven ammocoetes collected on August 16, 1954, from Pidgeon Creek, a tributary of the Conecuh River. The adults collected from Hurricane Creek were in the act of spawning and the larvae from both localities are apparently second-year larvae.

The above specimens compare favorably with the counts and dentition as given by Seversmith (COPEIA, 1953 (4) : 225–32).—LUTHER BANCROFT COOPER AND ANDREW FREDERICK HEMPHILL, *Department of Biology, University of Alabama, University, Alabama.*

CONTRIBUTION TO THE LIFE HISTORY OF THE SOUTH AMERICAN FISH *ARAPAIMA GIGAS.*—The arapaima, a member of the ancient group of osteoglossids, is found only in northern South America. Its close relatives are native to Sumatra, Borneo, Northern Australia, New Guinea and South America. Because it inhabits waters which flow through some of the wildest jungle areas of the world this fish's exact distribution is imperfectly known. Arapaima is generally regarded as the world's largest strictly freshwater fish and is known as piraruću in Brazil, paiche in Peru and arapaima in British Guiana. I had an opportunity to gather some information on this interesting species during an expedition sponsored by the Bingham Oceanographic Laboratory, Yale University, in January and February of 1953, to the Rupununi River at Karanambu or Karanambo in British Guiana.

The importance of arapaima as a commercial item and a valuable source of protein in several areas in South America is well known (Eigenmann and Allen, 1942, Fishes of Western South America: 336–45; Gudger, 1943, Sci. Monthly, 57: 500–13). It has been demonstrated (Anonymous, 1944, Colonias y Foresta, Ministerio de Agricultura, Lima, Peru) that the arapaima is exceptionally rich in nutritive value, but the natives of British Guiana do not care for it as a food, perhaps because many species of tastier fish abound. Hatcheries have been established in Peru and Brazil in order to study arapaima, and the biology of this fish in captivity has been covered by Fontenele (1948, Rev. Brasil. Biol., 8 (4): 445–59). However, very little has been published on arapaima's life history in its natural environment.

The older references written in Portuguese are difficult to obtain and deal mostly with exhaustive descriptions of the Indian methods of fishing, construction of their boats, spears, methods of drying fish, shipments, etc. The bits of information in these publications on the life history of the arapaima have been gathered mostly by hearsay and transcrip-

tion; at best they are confusing (Ihering, 1934, Da vida dos nossos animais—fauna do Brasil, and 1940, Dicionario dos animais do Brasil; Magalhães, 1931, Monographia Brazileira do peixes fluivaes; Verissimo, 1895, A pesca na Amazonia).

Arapaima gigas is found chiefly in the Amazon drainage of Brazil and Peru. It may also occur in the Amazonian tributaries of Venezuela and Colombia. The arapaima has infiltrated from the Amazon into the Essequibo River system of British Guiana, via the Branco and Takatu or Ireng Rivers into the Rupununi and Essequibo. During the heavy rains much of the lowlands are inundated; rivers merge and an exchange of ichthyofauna is possible. In the early 1840's Richard Schomburgk (1840–44, Travels in British Guiana) witnessed the capture of arapaima, by natives in the Rupununi. In the latter part of the same century the fish was reported by Quelch to have migrated to the vicinity of the mouth of the Potaro River (Roth, 1943, Fish Life in British Guiana: 4). At present the arapaima has extended its range as far north in the Essequibo (the river flows northward) as the first series of rapids between Rockstone and Bartica, roughly 65 miles from the sea. Also these fish inhabit the Rupununi up to the southern border of the Kanuku Mountains at Wichibai.

According to Edward McTurk, a highly intelligent observer who has lived in this jungle area most of his life, it is during April or May, when the Rupununi overflows its banks onto the savanna for miles around, that the arapaima spawn. They select shallow, clear, sandy areas minus vegetation to prepare the nests. McTurk has witnessed the activity, and stated that both parents participate in hollowing out the nest with their fins. We measured several old nests on dry ground, about a quarter of a mile from the river, and these averaged 20 inches in diameter and about six inches in depth. McTurk has seen several nests used in more than one season.

The fish are easily captured by natives of the Rupununi area with bow and arrow during their spawning activities in shallow water. Also, at other times, they provide tempting targets when rolling along the surface in the process of gulping air, an action which may be compared to that of the tarpon (Shlaifer and Breder, 1940, Zoologica, 25(30): 493–512). Many arapaima leave the river course during periods of high water and are trapped in shallow ponds and lagoons when the water recedes. McTurk contends that jaguars kill and eat them when the fish cannot escape.

We captured three specimens. A small female was seined which weighed 4 pounds, 2 ounces, and measured 22⅛ inches in length and 11¼ inches in girth. With 15 ft. lines attached to floats and baiting with 3 inch squares of arawana, *Osteoglossum bicirrhosum*, (arapaima appears to have a definite preference for this bait) we caught a male 5 feet ¾ inches long. Its girth was 28 inches and it weighed 93 pounds. The third and largest, a female weighing 148 pounds was captured by rod and reel using a 3-inch spoon as a lure. This specimen had a length of 6 feet 4 inches, and a girth of 38 inches.

Both the male and female appeared to have single gonads situated dorsally at the left posterior portion of the abdominal cavity. They seemed to lack full maturation by several weeks. The compressed, foliated ovary of the larger female preserved in formalin weighed 1 pound, 3 ounces, measured 13½ inches in length and 5 inches in width. By weighing and counting the eggs of a portion of the gonad, approximately 86,000 eggs, which ranged from .5 mm. to 3 mm. in size, were estimated to be present. The smaller female's immature ovary, ¼ inch in width and 2 inches in length, was situated in the same position and the foliations could be seen with the naked eye. The male's single testis did not appear to be quite so advanced in approaching ripeness as the ovary of the mature female. According to Fontenele (1948, op. cit.), during the reproduction period there is evidence of a second testis which is 1/10 the size of the other.

The air bladder is large and occupies the entire area dorsally above the abdominal cavity. It is composed of cellular, lung-like tissue, and is vascular with the walls richly supplied with blood vessels. The inner surface area is greatly increased by recesses or alveoli which have the somewhat spongy appearance of a true lung. The air bladder opens directly into the pharynx; in the large specimens the aperture accomodated the probing of a one-half inch branch with ease.

Stomach contents indicate *Arapaima gigas* to be an aggressive fish eater. The small specimen contained 5 hassar (probably *Callichthys littoralis*) up to 3¼ inches long. The male's stomach harbored fish bones mostly not identifiable, although it was possible to distinguish portions of a 12-inch lukanani, *Cichla ocellaris*. The stomach of the female was empty. The only other scientific information secured pertaining to the stomach contents of arapaima was from Mr. Herbert Allsopp, director of fisheries at Georgetown, British Guiana. He dissected two specimens harpooned by McTurk on November 12, 1952. One specimen's stomach was empty; the other contained a baira, *Cynodon scomberoides*, 16 inches long and another fish about 12 inches in length of doubful identification.

For many years the top weight of arapaima has been accepted as about 400 pounds. Not only do encyclopedias and dictionaries carry this information, but scientists and other writers, past and present, promulgate these weights. Gudger (op. cit.) and McCormick (Vesey-Fitzgerald and La-

Monte, 1949, Game Fish of the World) go into detail on this popular question of arapaima's maximum weight. McTurk, who has perhaps seen as many specimens as any other white man over the years in British Guiana, stated that he has never seen an arapaima that would weigh much over 200 pounds. Aside from our three specimens the only other arapaima measured and weighed in this area by a scientist were Mr. Allsopp's fish, a 6 foot 4½ inch female whose girth was 35 inches and whose weight was 148 pounds, and a male measuring 5 feet 7 inches in length and 32 inches in girth which weighed 113 pounds. Considering all the information available at this date, the maximum weight of *Arapaima gigas*, at least in the Rupununi and Essequibo of British Guiana, seems to be about 200 pounds with a length of approximately 7 feet. Further, there appears to be no scientific evidence that larger arapaima inhabit the Amazon. In my estimation there is still much doubt as to what is the world's largest strictly freshwater fish. Although comparative sizes of fishes by word of mouth, especially by natives, has small value, there was enough information in British Guiana to indicate the strong possibility that the arapaima may be exceeded in maximum size by one of South America's giant catfishes—the lau-lau, *Brachyplatystoma filamentosum*.

The Arapaima readily takes an artificial bait (spoon) either cast or trolled (Migdalski, 1954. Yale Sci. Mag., March). Although the fish has a sluggish appearance it displayed great resistance before being boated.—EDWARD C. MIGDALSKI, *Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut.*

EMBRYOLOGY AND EVOLUTION OF THE PELAGIC FISH EGG.—It has long been known that many species of marine fishes, and a few in fresh water, have free-floating pelagic eggs. The important role of floating eggs in ecology and distribution is well recognized, but the possible evolutionary history of this type of egg in the fishes has received little attention other than some rather desultory speculation. A recent paper by Shelbourne (1956, Journ. Mar. Biol. Assn. U. K., 35: 275–86) discussed certain characteristics of fish eggs and embryos from different ecological situations and suggested a new approach to the problem of the origin of the pelagic marine fish egg. The present note points out some exceptions to his characterization of the pelagic embryo, and offers some comments on the evolution and systematic interpretation of egg types in the fishes.

Shelbourne reviewed the contrasting characteristics of the three major ecological categories of fish eggs and embryos. Of these, freshwater demersal eggs and marine pelagic eggs differ most sharply. The former characteristically have denser yolk, the median finfolds of the embryo are low and thin, the integument is closely applied to the underlying tissue surfaces, and there is a more or less well developed circulation on the yolksac. Marine pelagic eggs, he stated, have a more dilute yolk, the embryo develops large inflated median finfolds with extensive fluid-filled subdermal spaces, and blood vessels do not develop on the yolksac. Characteristics of marine demersal eggs and their embryos fall variously between these two extremes.

Shelbourne postulated that, in order to achieve buoyancy, the yolk of the marine pelagic egg must be more highly diluted with fluid than is the yolk of a typical demersal egg. The yolk is utilized as embryonic development proceeds, but if the nonnutrient dilutent fluid were to be lost the egg would lose its buoyancy and sink. The fluid is retained by transferring it to subdermal spaces between the developing tissue layers over the yolksac and within the median finfolds that form along the body and tail. This retention of fluid results in great enlargement and inflation of the finfolds and of the covering over the yolksac and in a more or less conspicuous separation of the integument from the underlying tissues. He suggested that the open, fluid separation of the tissue layers in turn prevents formation of closed blood vessels in these regions during early stages, and that pelagic embryos thus do not have a vascular yolksac. The heart opens directly into an extensive subdermal sinus, and the free intercommunication of fluid through the subdermal spaces carries nutrient materials about and takes the place of the more usual closed-vessel circulation during early stages.

This interpretation of the embryonic basis of the pelagic egg was derived from Shelbourne's own embryological studies, supported by his extensive review of the literature on fish eggs and larvae. However, certain fishes he did not cite have pelagic eggs which do develop prominent blood vessels on the yolksac. These fishes, the allotriognaths and some of the synentognaths, are conspicuous exceptions to his key statement that the yolksac is not vascular in pelagic embryos. Examples described and figured in the literature include *Trachypterus taenia* (Lo Bianco, 1908, Mitth. Zool. Sta. Neapel, 19: 1–17), *Trachypterus cristatus* (Sanzo, 1918, R. Com. Talass. Ital., No. 65: 1–15), and *Lophotes cepedianus* (Sanzo, 1940, Mem. Com. Talass. Ital., No. 272: 1–6) among the allotriognaths; and *Oxyporhamphus micropterus* (as an "unidentified scomberesocid" in Delsman, 1924, Treubia, 5: 408–18) and *Scomberesox saurus* (Sanzo, 1940, Mem. Com. Talass. Ital., No. 276: 1–6) among the synentognaths. From materials studied at Scripps Institution I can confirm the occurrence of well-developed blood vessels on the yolksac in pelagic embryos of

both of these major taxonomic groups. These specimens include incompletely identified allotriognath embryos, and pelagic embryos of several species of synentognaths: *Oxyporhamphus micropterus*, *Cololabis adocetus*, *Exocoetus* sp., *Cypselurus xenopterus*, and two additional species of flyingfishes, not yet specifically identified. Although these are exceptions to Shelbourne's characterization of embryonic types, they do strengthen one aspect of his theory, for in all of the pelagic embryos with vascular yolksac known to me thus far the median finfolds are only moderately developed: hence these species agree with his finding that highly inflated subdermal spaces and vascularized yolksac are not known to co-exist. In the synentognath material under study at Scripps Institution, the forms with pelagic and with attached eggs, respectively, do not appear to differ in basic embryonic characters. The specimens studied are from plankton samples taken by Scripps vessels on several cruises in the eastern Pacific, chiefly the SHELLBACK cruise of 1952.

Judging from the present taxonomic occurrence of floating and non-floating eggs, it is apparent that transition from one type to the other must have evolved independently many times in fishes. This is certainly true even in the synentognaths, for within this order the species that are definitely known to have pelagic eggs are an obviously heterogeneous assortment that includes representatives of several divergent evolutionary lines, rather than a single group of closely related forms. Several other groups of teleosts, e.g., the clupeoids and the labrids, are also known to include species with pelagic and with demersal eggs. It is likely that egg type in fishes, in common with many other taxonomic characters, is of variable stability in different groups and that the nature and extent of variability that actually occurs in egg type depends on the nature of the particular group, as is true of taxonomic characters as a whole. From the known occurrences of variation in egg characters it seems clear that the character of floating or non-floating egg is reversible and that in general a stock characterized by either type could, at least theoretically, give rise to forms with the other type. Which kind of egg is more primitive and which is more advanced is a relative matter, and one's judgement on this will depend on how inclusive the group one wishes to consider—whether a particular genus of fishes, a certain family or order, or all of the lower chordates.

A change in egg type may be a major evolutionary event so far as the general ecology of the species is concerned, and yet be of relatively small apparent consequence in developmental morphology, for the embryo may simply continue to follow closely the stable developmental pattern that has long characterized its taxonomic group. The known exceptions to Shelbourne's categories of egg and embryonic characters suggest that secondary adaptive modifications in embryonic morphology may be inconspicuous or perhaps may lag behind the physiological changes that determine whether the egg sinks or floats. Although adaptive changes in the general life history may be quite extensive, they are governed by the limits of what is genetically possible for the particular group. There is already much evidence of stability of basic developmental characters throughout the lower vertebrates, and examples from quite diversified groups can be cited. The species of the scorpaenid genus *Sebastodes* are live-bearing, so far as their life histories are known, but their embryos and new-born larvae are essentially similar to comparable stages of the scorpaenids that spawn masses of floating eggs. Among the cyprinodont fishes, the egg-laying and live-bearing forms agree in essential developmental characters, though their ecological status is certainly different. The synentognaths with pelagic eggs agree in embryonic characters with their relatives that have attached eggs.

Since long-established embryonic characters obviously can be retained in spite of adaptive differences in egg ecology, some interesting questions arise concerning the possible value of stable embryonic characters as clues to past ecological history of certain extant groups of fishes. If there has been a major shift in the ecological conditions to which the egg is adapted, the embryonic characters might still show evidence of the former adaptive condition and hence might suggest the direction of change that the group has undergone in its life-history evolution. Thus, vascularization of the yolksac in a form with pelagic eggs might suggest derivation of that form from a stock that normally is characterized by demersal eggs. If so, one might ponder the question whether the allotriognath fishes have "always" had pelagic eggs or whether, instead, the vascular yolksac in present-day embryos of these fishes might be a retained basic character that stems from a prolonged evolutionary stage in which the ancestral stock comprised inshore forms that had demersal eggs. The allotriognaths are highly specialized oceanic fishes, and their affinities are still very uncertain. Any new clue, no matter how tenuous, through which to approach the problem of their origin and relationships certainly warrants further inquiry.

Speculation on the possible history of the pelagic fish egg would be little more than mental exercise unless it were backed by substantial information on the developmental morphology of the fishes in question. The early stages of fishes are still very incompletely known. Fish embryology is a much-neglected field, but its basic importance in systematics and evolution is sufficient to urge its more extensive study by taxonomists and to encourage use of a wider selection of fish materials in special-

ized studies by embryologists.—GRACE L. ORTON, *Scripps Institution of Oceanography, University of California, La Jolla, California.*

ANOTHER RECORD OF THE RARE SHARK, *EUPROTOMICRUS BISPINATUS*, FROM THE PACIFIC OCEAN.—On April 3, 1956, at a night-light station occupied by the research vessel CHARLES H. GILBERT of the Pacific Oceanic Fishery Investigations, a female specimen of an unusual pelagic shark, *Euprotomicrus bispinatus* (Quoy and Gaimard), 242 mm. in total length, was dipnetted by the authors. The position of capture was 32°46′N., 176°42′W., approximately 260 miles north of Midway Islands. The EDO fathometer indicated the depth of the ocean in that region to be about 2,600 fathoms, and the surface temperature was 62.5°F. When first seen, the shark was cruising slowly on the surface which was illuminated by the deck lights of the ship.

Recent descriptions of this rare and peculiar shark are given by Hubbs and McHugh (1951, Calif. Acad. Sci., Proc. IV, 27(6) : 159–76) and also King and Ikehara (1956, Pacific Science, 10(1) : 17–24).—TAMIO OTSU AND HOWARD O. YOSHIDA, *U. S. Fish and Wildlife Service, Honolulu, Hawaii.*

NOTES ON THE RESPIRATION OF SMALL *REMORA REMORA*.—On a recent equatorial cruise of the U. S. Fish and Wildlife Service vessel HUGH M. SMITH numerous specimens of the white-tipped shark *Pterolamiops longimanus* (Poey) were taken by handline. On March 22–23, 1956, at approximately 1°N. latitude and 140°W. longitude, two six-foot sharks bearing small sucker fish, *Remora remora* (Linnaeus), were landed. Three of the latter were transferred to a large plastic tub immediately after the sharks were captured. The tub was supplied with running sea water pumped directly from the ocean; thus the water had essentially the same temperature and dissolved oxygen characteristics as the natural environment. Despite these supposedly favorable conditions the remoras consistently evidenced peculiar respiratory behavior, not all of which could be ascribed to the shock of capture, handling, or confinement.

Upon being placed in the tub each remora at first swam slowly about, but very soon attached its sucking disc to the side of the tub just at the water's edge. The mouth and part of the head were exposed to the air, and respiratory movements consisted of rapid gulps in which some air was taken in and some water forcibly expelled from the mouth. The fish could be manually moved down the side of the tub with difficulty but usually returned quickly to the surface when not restrained. In those instances where fish remained submerged, their opercular breathing movements ranged from 135 to 244 expirations per minute (Table I). This rate appears to be relatively high, for the highest value in Norman's list (1949, A History of Fishes, p. 43) of rates for various species is 150 respirations per minute for the minnow *Phoxinus* and the stickleback *Gasterosteus*.

By chance it was found that a jet of water aimed at the remoras' open mouths caused the respiratory rate to decrease markedly, and the fish could then be pushed down the side of the container with little difficulty. They remained submerged as long as water was flowing over them, but rheotaxic behavior was not indicated since they did not orient themselves to the current when its direction was changed. By varying the rate of water flow a point was found at which the fish ceased all opercular movements and other external signs of respiration. Water was administered by a length of quarter-inch glass tubing placed about an eighth of an inch in front of the fish's mouth and connected to a faucet by rubber tubing. The rate of flow could be controlled quite easily and was measured by timing the interval required to fill a 1000 ml. volumetric flask. Several tests were made to determine the rate of flow necessary to stop external respiratory movements, and the results are presented in Table I. Of the various tests, numbers 3 to 8 are not given further consideration, as changing water temperature and other variables invalidated them for comparative purposes.

With flowing water, the volume of flow required to stop respiratory gill movements increased with increase in fish size (mean values of tests 1 and 2). Without flowing water, the number of respirations per minute decreased with increase in fish size. A measure of the interrelationship between these two phenomena can be obtained by dividing the flow rate (in ml. per minute) by the respiratory rate (in respirations per minute) giving an index in terms of milliliters of water per single respiration (Table I, column 5). These values are only relative since not all water aimed at the fish's mouth is presumed to enter. When the mean milliliter-per-respiration values (tests 1 and 2) are plotted against fish volume an almost perfect linear relationship is apparent. This admittedly should obtain because respiratory volume varies with the size of the branchial and buccal cavities, which in turn is dependent on the size of the fish. When respiratory volume is expressed as a percentage of fish volume the mean values of all three fish (tests 1 and 2, column 8) are 40 percent, this again being only a relative figure. Assuming that only half of the water from the jet actually enters the mouth, and that the respiratory rate in standing water is about 200 respirations per minute, then in one minute a small remora would pass a quantity of water equivalent to 40 times its own volume over its gills, certainly a remarkable achievement.

TABLE I

RESPIRATORY DATA FOR *Remora remora*
Fish A, B, and C were tested simultaneously in Test 1 and again in Test 2.

1 Fish, with its standard length and displacement volume	2 Test No.	3 Water temperature in degrees F.	4 Respirations per minute with no current applied	Rate of water flow required to stop opercular movements			
				5 In milliliters per minute	6 In miles per hour[1]	7 In ml. per respiration[2]	8 Ml. per respiration as percent of fish volume[3]
A	1	76.8	244	638	0.75	2.6	37
81 mm.	2	76.8	244	747	0.88	3.1	44
7.1 ml.	Mean		244	692	0.82	2.8	40
B	1	76.8	236	1143	1.34	4.8	40
98 mm.	2	76.8	236	1161	1.37	4.9	41
11.9 ml.	Mean		236	1152	1.36	4.8	40
	3	78.6	200	—	—	—	—
	4	77.0	210	—	—	—	—
	5	77.0	150	1186	1.40	7.9	66
	6	77.1	147	1215	1.43	8.3	70
	7	77.2	135	1136	1.34	8.4	71
	8	76.3	217	1095	1.29	5.0	42
	Grand mean		191	1156	1.36	6.6	55
C	1	76.8	203	1357	1.60	6.7	46
103 mm.	2	76.8	203	1007	1.18	5.0	34
14.5 ml.	Mean		203	1182	1.39	5.8	40

[1] Calculated from flow per unit time through quarter-inch glass tubing.
[2] Calculated by dividing the figure in column 5 by that in column 4.
[3] The figure in column 7 as a percent of the volume given in column 1.

The fact that when remoras are not provided with an artificial stream of water the breathing rate is higher for small individuals suggests that smaller specimens either require more oxygen, have less efficient gills, or relatively smaller buccal and branchial cavities. It has already been demonstrated that the relative amount of water passed per resting respiration is exactly proportional to fish volume, a not unexpected situation, eliminating one possible reason for the higher rate of small fish. Of the remaining two, less efficient gills or greater respiratory need, the latter is more attractive as generally metabolic rates are higher in smaller individuals of a given species.

It is difficult to state how much the exciting and debilitating effects of capture and confinement contributed to the behavior outlined above. The first remora taken (Fish B) was confined for 28 hours and apparently was in good condition at the end of this period. The other two were captured 20 hours after Fish B, and were found dead in the tub after 21 hours of confinement. They were under observation for the first 15 hours of this period and appeared normal thoughout that time; they died during the night when the supply of circulating sea water was shut off. All three fish were in a state of excitation when first placed in the tub but appeared to adjust to the new environment quite rapidly.

Several extrapolations from the tabulated data and the described behavior are worthy of comment. It would appear that remoras may obtain other benefits from shark-riding than just transportation and the chance to dine with a shark. Their aquarium behavior suggests that they may require rapidly moving water to convey dissolved oxygen to their gills, and that they have become so adjusted to this service that an inordinate expenditure of energy (in the form of rapid respiratory movements) is required when in quiet water. Some evidence for this is the fact that Fish B survived a night in circulating sea water whereas Fish A and C died the next night when the water was shut off (Fish B had been preserved in the meantime).

One would expect this limitation to be reflected in either the respiratory anatomy or physiology of *Remora*. Apparently little is known about the physiology of echeneids. Gray (1954, Biol. Bull., 107(2) : 221) has calculated the gill area of *Echeneis naucrates* and ranks the species ecologically with the cutlass fish (*Trichiurus*), the butter fish (*Poronotus*), and other "fishes of moderate activity" living around piers or spending some time resting on the bottom.

Willem (1951, Bull. Inst. Roy. Sci. Nat. Belg., 27(8) : 1–6) noted the unusual development of the respiratory musculature of *Echeneis naucrates* and concluded that the species must pass a considerable volume of water with each expiration which is certainly in accordance with the present findings for *Remora*. Gross examination of the preserved experimental specimens and others caught subsequently revealed no outstanding branchial differences between *Remora* and more generalized fishes.

From these lines of evidence *Remora remora* appears to be somewhat comparable to the Atlantic mackerel (Hall, 1930, Am. Jour. Physiol. 93(2): 420) in that it requires a swift passage of water over its gills and cannot cope with confinement in still water. On the other hand, various echeneids have been maintained in the Honolulu Aquarium for several weeks without difficulty (personal communication from Spencer Tinker, the Director).

When the rate of water flow required to stop opercular movements is expressed in miles per hour, a very peculiar result is obtained (Table I, column 6). It would superficially appear that larger remoras require faster currents than smaller specimens, in contrast to the measurements of respiratory rate and the situation found in nature. In my experience small echeneids are nearly always found attached to moving objects whereas the largest specimens seen were three-foot *Echeneis naucrates* found free-swimming around piers in the Marshall Islands. The conflict between these observations stems from the fact that computed water speed was derived from flow through glass tubing and not through the fish's buccal cavities. The cross-sectional area of the latter increases with increasing fish size whereas that of the former is constant. Water speed decreases upon leaving the tube orifice and entering the relatively large buccal cavity, the decrease becoming greater with increasing fish size. The speed of water flow calculated for the smallest remora (Fish A) most closely approximates the actual speed through the mouth, whereas those for Fish B and C are increasingly in error.

A final question has to do with whether the speed of flow determined for Fish A can be used as an approximation of the average swimming speed of white-tipped sharks. Efforts to time these sharks as they circled the drifting HUGH M. SMITH were not particularly successful in that the sharks often loitered over garbage, pursued irregular courses, or disappeared from view. A speed of about one mile an hour is certainly within the capabilities of *Pterolamiops longimanus* and may well approximate its normal cruising speed.—DONALD W. STRASBURG, *U. S. Fish and Wildlife Service, Honolulu, Hawaii.*

PROTOLOPHOTUS, A NEW GENUS OF ALLOTRIOGNATH FISH FROM THE OLIGOCENE OF IRAN.—While preparing a systematic revision of the ribbonfishes and oarfishes (Trachipteridae) the writer found it necessary to refer to the morphology and systematics of members of related familes. According to Briggs (1952, COPEIA, (3) : 206–07) the family Lophotidae comprises three living species in two genera, *viz.*: *Lophotus lacepedei*, *L. capelli*, and *Eumecichthys fiski*. Fossil remains from the Oligocene of Iran (Persia) were described by Arambourg (1944, Bull. Soc. Géol. France, sér. 5, 13: 287–88, pl. X, figs. 1, 2) as *Lophotes elami*. It is the writer's opinion that the fossil form should be assigned to a separate genus. The significance of the new genus in the phylogeny of the Lophotidae, Trachipteridae, and Stylephoridae will be discussed in a future paper by Walters, Fitch, and Backus.

Protolophotus, gen. nov.

Genotype: *Lophotes elami* Arambourg (1944, *loc. cit.*) from the Elam beds (Louristan) of Iran. The species is known from a nearly complete skeleton of 420 mm. and the anterior part of a head with dorsal fin and rostral process,

Diagnosis: A lophotid in which the pelvic fins are well-developed and the pelvic girdle is fairly well ossified; the pelvic bone is slender and extends beyond the post-cleithrum, resembling the condition in trachipterine fishes of the same length. The pelvic fins are inserted close to or on the midventral line and are located at a distance from the pectorals. Dorsal fin base continues forward on a rostral process, anterior to the mouth. Vertebrae 65 + 14 = 79; anal fin beneath 68th vertebra. Vertebrae following anal fin with club-shaped haemal spines. All vertebrae of about the same length. Dorsal fin with 167 rays.

By contrast adult living lophotids have the pelvic fins, when present, weak and located on the sides of the body, immediately below and behind the pectoral fins; there are 140–150 vertebrae and 223 or more dorsal rays.

The new genus resembles the others of the family in having all vertebrae of about the same length, in having club-shaped haemal spines posterior to the anal fin, in having been scaled (Goin and Erdman, 1951, COPEIA, (4) : 285–88 describe cycloid scales in *L. capelli* = their *L. lacepedei*), in having a forwardly-produced dorsal fin base, and in pectoral, pelvic, and anal fin ray counts. The ventrally-situated pelvic fins are characteristic only of the larval stages in existing members of the Lophotidae (cf. Sanzo, 1939, Arch. Zool. Ital., (26): 121–29, tab. 6, figs. 1–3, and 1940, Mem. R. Com. Talass. Ital., 272: 6 pp., figs. 1–5).

Protolophotus elami (Arambourg)

Diagnosis: The development of the rostral process is similar to the condition in *L. lacepedei* as are also the development of the first dorsal ray and the

contour of the fin (cf. Briggs, *loc. cit.*).—VLADIMIR WALTERS, *The American Museum of Natural History, New York 24, N. Y.*

NORTHERN RECORD OF THE SNAKE EEL *OPHICHTHUS GOMESI* (CASTELNAU). —Shortly after sunset on July 16, 1954 the R/V ATLANTIS was hove to in 40 fathoms at 40°32'N, 70°54'W (50 miles S of Gay Head, Mass.) when 3 eels were seen swimming at the surface close by the vessel's hull. They were separated from one another by distances less than their length. Two of the eels had disappeared when the writer returned with a dipnet but the remaining one was caught. About one-half hour later, a blue shark (*Prionace glauca*), which had been in the vicinity of the vessel for several hours was caught and a second eel was removed from its stomach. It was obvious from the latter eel's condition that it had been very recently swallowed and may have been one of the uncaught two earlier seen. The eels prove to be specimens of *Ophichthus gomesi* (Castelnau), 472 mm. and 374 mm. in total length respectively. Both are females and appear to have recently spawned. A few ripe eggs about 1 mm. in diameter and pale yellow in color had been retained.

This eel is easily separated from its congeners by the long tail (61 and 60 hundredths of the total length in the present specimens) and by the characteristic dentition and coloration (see Ginsburg, 1951, Tex. Jour. Sci., 3(3) : 466–67 and 478). According to Ginsburg there is not much good information on the habitat of this species, but it appears to be known mainly from shallow coastal waters. It occurs most commonly from Florida to Brazil, although there is a record for Charleston, S. C., the northernmost heretofore. Thus this species should be added to the lengthy list of weak-swimming tropical and subtropical animals which appear during the summer in Atlantic shelf and coastal waters off northern United States and southern Canada. The means by which these animals are transported thither is as yet little understood since the popular supposition that they are carried north by the Gulf Stream, although perhaps correct, is insufficient to explain their presence in waters many miles inshore of the Stream's direct effect.—RICHARD H. BACKUS, *Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.*

Contribution No. 854 of the Woods Hole Oceanographic Institution.

THE CEYLONESE CYPRINID GENUS *EUSTIRA* GÜNTHER CONSIDERED A SYNONYM OF *DANIO* HAMILTON.—In discussing the classification of the danios, Myers (1953, Aquarium Jour., 24: 235–38) drew attention to numerous gaps that still remain to be filled before final word can be said as to their classification. Recently, while studying the nomenclatorial status of certain genera of Indian fishes, it was found that one of the Ceylonese genera ascribed to different positions in the system by various ichthyologists needed more scrutiny. The genus referred to is *Eustira*, described by Günther (1868, Cat. Fishes British Mus., 7: 331), to include a new cyprinid fish from Ceylon named by him *Eustira ceylonensis*. Günther placed *Eustira* under the group "Abramidina" of the family Cyprinidae and described it briefly as follows: Body oblong, much compressed, the entire abdominal edge being trenchent, scales of moderate size; lateral line abruptly bent downwards behind the pectoral fin; mouth obliquely directed upwards; barbels none. Dorsal fin of moderate length, without spines, opposite the anal; anal fin long, many rayed, caudal fin forked, pectorals elongate; ventrals well developed. Pseudobranchiae; gillrakers fine, lanceolate, rather widely set. Pharyngeal teeth 5.3.2–2.3.5, uncinate, not denticulated.

The fin rays and scale counts of *E. ceylonensis* were given by Günther as "D. 12. A. 17. V. 7. L. lat. 35. L. transv. 7–1/2/2," and the origin of the dorsal fin was noted as being slightly in advance of that of the anal fin. The species was also characterized as having pectoral fins shorter than the head, reaching only as far back as the pelvics.

Because of the slightly inadequate descriptions of the genus and the species, *Eustira* has been confused with *Chela* Hamilton, *Laubuca* Bleeker, and *Perilampus* Day (*nec* McClelland), by Day (1875–78, Fishes of India), Weber and de Beaufort (1916, Fishes of the Indo-Australian Archipelago, 3), Deraniyagala (1930, Eventognathi of Ceylon, and 1952, Coloured Atlas of Some Vertebrates from Ceylon, 1), Smith (1945, Bull. U. S. Nat. Mus., 188), and others. In fact, while recognizing *Eustira* as a subgenus of *Laubuca*, Weber and de Beaufort (1916, *op. cit.*, 48) remarked: "We do not think that the genus *Eustira* is generically distinct from *Laubuca*; we therefore give it only the value of a subgenus, containing *Eustira ceylonensis* Gthr. and our *Eustira maassi*." They distinguished the subgenus *Eustira* from *Laubuca s. str.*, by the downward curvature of the lateral line behind the pectorals, abrupt in *Eustira*, gentle in *Laubuca*.

While considering *E. ceylonensis* as a synonym of *Chela laubuca* Hamilton, Deraniyagala (1930, *op. cit.*) in a footnote commented on its doubtful similarity to species of *Danio*; but in his latest work on Ceylon fishes (Deraniyagala, 1952, *op. cit.*), he once again treated *E. ceylonensis* as a synonym of *Chela laubuca*.

In view of these conflicting views on the systematic position of *Eustira* and due to the fact that no additional material of the orthotype has been recognized from Ceylon since it was first described, a reexamination of the type material in the British Museum (Natural History) seemed desirable. Fur-

Fig. 1. *Danio malabaricus* (Jerdon) drawn from the holotype of *Eustira ceylonensis* Günther

thermore it was felt that this would help in clarifying certain discrepancies in the descriptions of the genus and species by Günther. The type series consists of six specimens cited as purchased from Mr. Cumming, from Ceylon.

While on a visit to England, the late Dr. S. L. Hora kindly examined for me the types of *E. ceylonensis* in the British Museum. In a letter dated September 23, 1953 he informed me that in "Günther's specimens the origin of D. is slightly in advance of A.; number of branched anal rays 15; scales transversely 8/1/2." No figure of *E. ceylonensis* has been published. This deficiency has now been remedied by an excellent figure of the type specimen (Fig. 1), sent to me by Dr. Ethelwynn Trewavas of the British Museum. The two pairs of rudimentary barbels, present in the specimens and shown in the drawing, escaped Günther's attention, for he characterized *Eustira* as being devoid of barbels. During my visit to the British Museum in July, 1955, I was able to reexamine once again the type material and to verify the points mentioned above. I now find that in the following important characters *Eustira* differs from *Chela* as the latter genus is defined at present (Silas, MS).

1. The dorsal fin originates ahead of the anal fin, rather than behind the front of that fin.

2. There are two pairs of barbels (none in *Chela*).

3. The pectoral fins are shorter than the head, instead of being elongate and much longer than the head.

4. The abdominal margin is rounded, rather than being keeled.

Eustira is obviously distinct from *Chela*, and its rounded abdominal margin separates it from all other cultrate genera of the subfamily Abramidinae. The combination of characters mentioned above places *Eustira* in the Rasborinae. In fact, *Eustira* fully agrees with the description of one of the well-known genera in this subfamily, namely *Danio* Hamilton. There is not a single character by which the two nominal genera can be said to differ. Hence I propose that *Eustira* be considered a synonym of *Danio*.

Only one species of *Danio*, namely *D. malabaricus* (Jerdon) is known at present from Ceylon, although the exact status of the Ceylonese form in relation to the typical form of the Cauvery drainage in southern India needs elucidation. The type specimen of *E. ceylonensis*, figured here, shows in addition to the two pairs of barbels, the following characters not noted by the original author: the pelvic fin has 8 rays (i, 7); the anal fin has 18 rays (iii, 15), the last ray divided to the base; the caudal fin has 19 rays. Taking all these data into consideration, there is not a single character by which *E. ceylonensis* can be separated from the Ceylonese form, or representative, of *Danio malabaricus*, to the synonymy of which it is here relegated.

The subgenus of *Laubuca* to which Weber and de Beaufort misadvisedly assigned the name *Eustira* is thus left without a valid name. The problem is under further study.

I wish to thank Dr. Carl L. Hubbs for going through the manuscript and Drs. Sunder Lal Hora and Ethelwynn Trewavas for the help rendered.—
E. G. Silas, *Scripps Institution of Oceanography, La Jolla, California.*

Reviews and Comments

THE GILA MONSTER AND ITS ALLIES: THE RELATIONSHIPS, HABITS, AND BEHAVIOR OF THE LIZARDS OF THE FAMILY HELODERMATIDAE. By Charles M. Bogert and Rafael Martín del Campo. Bulletin of the American Museum of Natural History, 109(1): 1–238, 20 pls., 35 figs.—At last there is available a monograph on *Heloderma* such as is deserved by this unique lizard, the only venomous genus among the great number comprising the saurian order. Even recently there have been a number of uncertainties concerning this creature, true, not uncertainties to those most conversant with it, but uncertainties prolonged by current popular natural histories: Is *Heloderma* really venomous? Is it dangerous to man, and have there been any actual fatal cases not subject to extraneous explanations of the fatality? Is *Lanthanotus*, of southeastern Asia, a close relative of *Heloderma*, and is it likewise venomous?

This authoritative work leaves no doubt as to the answers to all these questions, and it is to be hoped that writers of popular articles on the reptiles of the Southwest who may discuss the Gila monster and its Mexican cousin, the beaded lizard, will no longer leave uncertainties on these points in the minds of their readers. The two species of *Heloderma* are, indeed, venomous and, as far as is known, they constitute the only two venomous lizards in the world today. *Lanthanotus* is not a close relative; neither is it venomous, as was, indeed, shown in a previous work of which the senior author of this paper was a coauthor (McDowell and Bogert, Bull. Am. Mus. Nat. Hist., 1954, 105). The bite of the Gila monster can be serious; and a few human fatalities, largely or entirely caused by its venom, are of record.

This monograph is much more than a mere taxonomic survey of *Heloderma*, although that part of the presentation is ample and thorough, involving as it does the description of three new subspecies. The general subjects of habits, life history, ecology, the effects of the bite, the folklore are thoroughly discussed, and show the results of extensive research into all of these fields.

The monograph begins with a review of the earliest printed descriptions of *Heloderma*, first of the southern species *horridum*, followed by *suspectum* in 1859. The fossil record is outlined, including mention of a fossil helodermatid lately found in Europe. Then, after a discussion of the characters useful in classification, there follows a thorough taxonomic survey of the genus, including not only morphologic descriptions but data on habitats, ranges, and locality records. The new subspecies described are *H. h. alvarezi* from Chiapas, *H. h. exasperatum* from the Sonora-Sinaloa border (a disjunct population), and *H. s. cinctum* from western Arizona, southeastern Nevada, and extreme southwestern Utah.

Maximum lengths, always of popular interest, are given; it is shown that the southern species grows to a greater length than the northern. Other differences between *horridum* and *suspectum* are surveyed, including certain basic osteological features. All doubts as to validity of considering the two species to be distinct are laid at rest. Complete tables of characters as well as keys, are given, and the taxonomic survey concludes with an interesting discussion of clines in subspecific entities. In this discussion the population, rather than the nomenclatorial viewpoint is stressed. The unfortunate results of taxonomic surveys that tend to pigeon-hole populations by names are set forth.

The probable effects of temperatures and rainfall on ranges are considered. It appears that the genus can only exist in arid climates where rainfall is primarily concentrated in the summer, which the authors believe the explanation of the absence of Gila monsters from the California deserts. It is not clear why *suspectum* fails to range farther east in New Mexico than it does.

The discussion of habits includes a food survey, which is especially adequate in the case of *suspectum*, since more observations are available on this species. The senses used in locating foods are treated.

The authors reach the conclusion that the fat storage in the tail is valuable only for food storage and not for the production of oxidative or metabolic water. Some might question this theory, believing that in carbohydrate reduction the net gain in the metabolic water may be material.

The tooth replacement method is discussed and suggests that corresponding work should prove of value in other genera.

The authors have painstakingly gathered an extensive series of life history notes on feeding, mating, etc., based on observations both in the field and on captive specimens. The normal temperature activity range was ascertained by study of captive specimens. There is a good survey of heat as well as moisture requirements.

The conclusion is reached that procrypsis is the

most important factor in this lizard's development of pattern and color. The warning-coloration theory is considered but is not deemed important. The authors have not given particular attention to the value of protective reflectivity as opposed to matching or concealing coloration.

Probably most readers will find the thorough discussion of the venom of *Heloderma* and the effects of its bite to be one of the most interesting parts of the book. As has long been known, venom is present only in glands of the lower jaw, with a relatively inefficient means (grooved teeth) for injecting it into the victim. The authors conclude that the venom is of value to its possessor primarily as a factor in defense rather than to secure prey, as is its purpose in venomous snakes. The reasoning is based primarily upon one power that the Gila monster has which venomous snakes lack, namely, the ability to kill its prey almost instantly by the crushing action of its powerful jaws, long before the venom could become effective and also before the lizard could be injured by a bite of the victim. The venom of the snake not only prevents the victim from retaliation dangerous to the snake, but also provides digestive enzymes that are dispersed by the victim's blood stream through its body before death, thus aiding in digestion. No doubt the venom of *Heloderma* also has its digestive effect, but the crushing action of the jaws is probably so destructive that the venom has little opportunity to spread via the blood stream. Furthermore, the very destructive action of the jaws must, to a certain extent, result in partial mastication, which is beyond the power of any venomous snake.

There is an extensive history of the experiments with *Heloderma* venom, and those who have not made a special study of reptile venoms will be surprised at the amount of research on this venom in the past. The importance of the efficiency of the venom-injecting apparatus of any poisonous creature, as opposed to the toxicity of the venom in determining the danger from its bite, is shown by the uncertainty regarding the venomous character of *Heloderma* that existed for so many years. It has been the ineffective bites that have led to doubts as to the presence of a real venom. Certainly any one who ever experienced the pain involved in an effective Gila monster bite (I have not, but I have had first-hand information from several victims) would entertain no doubt as to its venomous nature. The many uncertainties that exist in the case of snake bite, depending on factors inherent in the snake, in the victim, and in the circumstances of the bite are existant in the case of *Heloderma* bite also, with the additional factor introduced by the extremely inefficient means for venom injection. However, it is shown that even though venom is contained only in the glands next to the grooved teeth of the lower jaw, nevertheless, because of the strong jaws and the tendency of the lizard to hang on to its victim, the upper teeth may aid in increasing the injection.

It is pointed out that with so slow and lethargic a creature as the Gila monster, people are much less often bitten in what is truly an accident than is the case with snakes. Most of the bites suffered by humans have resulted from deliberately handling Gila monsters.

The authors summarize all the *Heloderma* bite cases that have come to their attention, either in the literature or elsewhere. These cases total 34. Eight out of the 34 cases were fatal, but the authors are quick to point out that these figures should not be taken as any criterion of the mortality ratio to be expected from *Heloderma* bites, for the obvious reason that the majority of minor bites are never reported. Further, some of the fatalities listed were doubtfully chargeable solely to envenomation. But it is demonstrated that under exceptional circumstances death may ensue. The venom is neurotoxic. The authors discuss first-aid and hospital measures. No antivenin is available, for the obvious reason that the total number of bites would not justify its preparation.

There is an extensive discussion of myths, misinformation, and folklore, including some novel items and some that have long been heard by every Westerner around the campfire. The odor and poisonous breath, spitting venom, the sting, the incomplete digestive tract, and other amusing tales are mentioned. Many of these, of course, have their counterparts in snake lore. Such matters as vernacular names, therapeutic products from the Gila monster, its commercial value, and methods for its conservation, are given adequate attention.

There are many excellent illustrations, especially a series showing the pattern differences of the several subspecies.

This book is a most satisfactory account of the Gila monster, and is one to be welcomed by every western naturalist. It concludes with a voluminous bibliography containing both scientific and popular references. In my opinion, the most important deficiency in the work is the absence of an index. One would certainly have been justified in so definitive a work.—LAURENCE M. KLAUBER, *233 West Juniper Street, San Diego, California.*

THE DISTRIBUTION OF FISHES FOUND BELOW A DEPTH OF 2000 METERS. By Marion Grey. Fieldiana: Zoology, 36 (2); 75–337, 4 figs. (price not stated).—This work summarizes the present-day knowledge of the geographical and bathymetrical distribution of the deep-abyssal

fishes. It is primarily a compilation from the literature and suffers from the weaknesses which characterize checklists prepared in this manner. It is, however, much more than a checklist. Valuable synonymies are presented for all of the more than 350 deep-sea forms treated; information concerning the distribution of the individual species and the size of the known specimens is provided; juicy little facts and evaluations, many of them hitherto unpublished, appear as remarks; and under family headings there is usually a brief and succinct statement as to the place of the group in the deep-sea fauna.

The first 17 pages comprise a general discussion in which the author has made a valiant effort to distill an essence of generalities from a great mass of data accumulated from the scattered literature. The result is interesting and stimulating, but in certain sections not entirely convincing. Mrs. Grey is the first to admit that this is not a definitive work and that much more information is required before we can have any clear conception of the life and distribution of these deep-sea fishes. The probable capture of numerous species in bottom trawls while these were being retrieved makes it uncertain whether we are dealing with benthic or pelagic species in many cases; the paucity of really deep hauls renders the delimitation of zoogeographical regions tenuous; in most species the limited number of specimens captured places any arguments for endemism on rather shaky ground. However, a bold attempt has been made in all of these directions, and the results constitute a marked step forward and a new position from which the investigations of the immediate future can depart.

I have no doubt that the work will be roundly cursed for its shortcomings, but I am equally sure that it will be used as a valued tool by those who berate it. The faults are not to be attributed to Mrs. Grey, but to the earlier authors who so often neglected to provide her with the necessary information.—ROLF L. BOLIN, *Hopkins Marine Station, Pacific Grove, California.*

AMPHIBIANS AND REPTILES OF GEORGIA. *By Bernard S. Martof. University of Georgia Press,* Athens. 1956. 94 pp. $2.00 (paper).—This little pamphlet has two major parts. The longer part consists of keys to the native and introduced amphibians and reptiles of Georgia. The keys seem to be workable and the characters thoughtfully selected. Simple drawings illustrate many of the diagnostic features. Ranges are given in general terms within the state. The other major part is a check list with some indications of the apparent relative abundance of the 202 forms included. In addition to an introduction, there are a glossary, list of references, and short statements on snakebite treatment and preservation of specimens.

Martof intended the work as a guide to the Georgian herpetofauna for amateurs. It should serve that purpose well and satisfies this need for the first time.

The title on the cover and the price, however, seem to indicate a greater comprehensiveness than is actually warranted.—ARNOLD B. GROBMAN, *Florida State Museum, Seagle Building, Gainesville, Florida*

LES METAMORPHOSES DES BATRACIENS. By Paul C. J. Roth. Dunod, Paris, 1955: ix + 98, numerous unnumbered text figs. No price listed.—This volume is another in the scientific primer series edited by Roger Simonet and planned to introduce science to the general public as an active and exciting field through accounts of present day research. The book is made up of two parts. The first, which consists of but two chapters, reviews the phenomena of natural metamorphosis in the amphibians. The second part, comprising the bulk of the work, is concerned with experiments relating to metamorphosis and is based to a large extent on the author's own researches. He emphasizes the variables he considers most important in studies of this nature, namely, the relative age of the individual, the medium in which it is kept, the dosage of the hormone, and the effect of the seasonal rhythm. To study the last he used tadpoles of the midwife toad, *Alytes obstetricans*, which may hibernate and metamorphose the following spring. When he kept them in aquaria under conditions of food and temperature to prevent hibernation he found that metamorphosis was still delayed. Experiments on these aquarium tadpoles demonstrated that those treated with hormones in the fall required 28 to 35 days to complete metamorphosis after a latent period of 13 to 14 days, while those treated in April required only 14 to 15 days after a latent period of 6 to 8 days.

Following the four chapters on experimental metamorphosis there are two short chapters on neoteny and arrested metamorphosis. The book closes with a *Commentaries et Conclusion* and a bibliography.

It seems to me that it would be better not to include environmentally enforced reproduction in the larval state, such as occurs commonly in the genus *Ambystoma*, and genetically fixed reproduction in the larval state, such as occurs in the perennibranch salamanders, under the single term neoteny. I would prefer to restrict neoteny to the former condition and use paedogenesis for the latter.

The proof reading leaves something to be desired

and the bibliography cannot be said to be a complete coverage of the subject. For example, the excellent, comprehensive review: "The thyroid gland and its functions in the cold-blooded vertebrates," by W. Gardner Lynn and Henry E. Wachowski (Quart. Rev. Biol., 1951, *26*, 123–168) received no mention.

This little book is a pleasant and adequate introduction to the subject of amphibian metamorphosis. I believe that volumes of this sort perform a valuable function, not only in introducing science to the layman but also in permitting professional biologists to obtain a grasp of the overall picture of those aspects of biology in which they themselves are not specialists.—COLEMAN J. GOIN, *University of Florida, Gainesville, Florida.*

OLD FOURLEGS, THE STORY OF THE COELACANTH. By J. L. B. Smith. Longmans, Green and Co., London, 1956. $2.94. Published in the U. S. as THE SEARCH BENEATH THE SEA by Henry Holt and Co., New York, 1956: xi + 260, 7 pls., $3.95.—These two titles identify the same work except that the dust jackets are different and the New York printing contains an author's note about the recent death of Captain Eric Hunt. Aside from the notable difference in price, the London product is preferable because the plates are reproduced on a much better quality paper.

Despite its title, this book is as much an autobiography as it is an account of the coelacanth. Its general appeal would have been greatly enhanced had there been more emphasis on the latter. The first chapter entitled "The Stage is Set" is mainly concerned with the trials and sufferings of the author in his early life.

Chapter two, "Thirty Million Generations" gives a rapid, simplified account of the origin of the earth, the beginning of life, and, finally, the development of the higher animals. The vertebrates are introduced with a paragraph on the agnath fishes (p. 15). This is followed by a description of the crossopterygians which, unfortunately, are given the credit for the development of such fundamental structures as true bony jaws, bony skeleton, and overlapping scales. In spite of the necessity for a condensed account, the placoderms should not have been ignored since the above structures were first developed in that group, even to the overlapping scales (if restorations of such forms as the Antiarchi are correct). It would not have detracted from the importance of the coelacanth to have placed it more accurately in the scale of fish evolution. The mere wonder of its survival and the fact that it has undergone so little structural change is enough to secure this marvelous creature a unique place in the history of biological events.

The most dramatic and interesting portion of the book begins with chapter three entitled "Cinderella" in reference to Miss M. Courtenay-Latimer, to whom the volume is dedicated. As the author points out, the first coelacanth was saved only through her intelligence and determination. The detailed account of the happenings that took place in the small South African port of East London back in 1938 is fascinating reading.

The drama is continued through the succeeding chapters which deal with the identification of the fish as a coelacanth by Smith (and his emotional reactions when the significance of the discovery dawned upon him), troubles with the Press, and the production of his detailed scientific paper on what remained of the animal. To the lasting credit of the author, he was not satisfied with the first specimen but instigated an intensive search for others which stretched over a period of fourteen years. As a direct result of his personal publicity campaign, a second individual finally came to light in 1952. It was entirely fitting, therefore, that this individual also was received by Smith for study. Even more important than the taking of another specimen, this second discovery served to locate an entire population of coelacanths in the vicinity of the Comores Islands.

The developments which followed the capture of the 1952 coelacanth bring up a question of scientific ethics in these times when the rule has been a healthy freedom of exchange of both material and information. Although this point was not overly emphasized by the author, it is one that needs attention. According to Smith, he was forced to abandon his well-laid plans for collecting at the Comores due to the refusal of the French authorities to grant permission for this activity. This was done despite an offer by Smith to fully share all of the material as well as the techniques. Also, the author generously offered to share his relatively intact specimen from the Comores with qualified specialists all over the world. So far as is known, the French have succeeded in taking seven more coelacanths, all apparently at the Comores, yet all are being worked on by French scientists and, so far, only a little information has been released. Whether science will benefit from such a procedure, remains to be seen.

The book closes with the series of events precipitated by the capture of the second coelacanth. Of particular interest to ichthyologists is the information that the 1952 specimen, named *Malania anjouanae*, was apparently an unusual variant and that later individuals all closely resembled the 1938 fish. As the author points out, *M. anjouanae* is probably congeneric with *Latimeria chaulumnae*. It may even be the same species.

There are no fewer than five appendices. The

first is an interesting general account of how the coelacanth compares with modern bony fishes. The second gives supplemental information on the question of why the discovery of *Latimeria* aroused such wide interest among biologists. The third gives the very latest information available about coelacanths including the text of two short papers which appeared in *Nature* in 1955, one by J. Millot in February and the other by J. L. B. Smith in September. The last two appendices are devoted to the reprint of a newspaper article and the text of a radio broadcast, both concerned with the discovery of the second coelacanth.

This book is an interesting and often dramatic account which will have significance for the professional biologist but probably limited appeal for the general reader unaware of the impact of "Old Fourlegs" upon modern biological thought.—JOHN C. BRIGGS, *Department of Biology, University of Florida, Gainesville, Florida.*

IOWA FISH AND FISHING. By James R. Harlan and Everett B. Speaker. State of Iowa Printing Board, Des Moines, third edition, 1956: x + 377, 10 figs., 22 pls. (18 in 4-color), and many text illus. $2.50.—The first edition of this popular book was reviewed in COPEIA (1951, No. 3: 253). This revised and much augmented edition adds 9 new color plates by Maynard Reece and three chapters (on bait and baiting, fishing tackle, and distribution of Iowa's fishes) for a total of 140 additional pages; this is approximately a 60 percent increase over the size of the initial volume. Of particular interest to ichthyologists is the new section on distribution by R. E. Cleary, which includes individual maps for 97 of Iowa's 133 species (distributional data for all species are given in the text). The 18 fine color plates illustrating 63 species are available separately from the text in poster and portfolio form. Two poster sheets, each 22½ by 34½ inches, include the full set of plates and are especially designed for classroom use; the portfolios consist of the 18 plates individually mounted on heavy paper. Both sets are mailed postpaid for $2.00 by sending cash, check or money order to the State Conservation Commission, East 7th and Court Avenue, Des Moines.

Nomenclatural changes include the listing of *Esox vermiculatus* as a subspecies of *E. americanus*, assigning of *Clinostomus* to the genus *Gila*, the synomymizing of *Hybognathus placita* with *H. nuchalis*, treating *Ameiurus* as a synonym of *Ictalurus*, and *Schilbeodes* of *Noturus*, modifying *Pilodictis* to *Pylodictis*, placing the four species of American serranids entering fresh water in *Roccus*, changing *Morone interrupta* to *Roccus mississippiensis* and *Chaenobryttus coronarius* back to *C. gulosus*, synonymizing *Hadropterus* with *Percina* and *Crystallaria* with *Ammocrypta*. Reasons for these changes and for the modified subspecies nomenclature followed are given in the check-list. One species, *Hybopsis plumbea*, is added to the state fauna. This book is an excellent buy for anyone interested in fishes.—ROBERT RUSH MILLER, *Museum of Zoology, Ann Arbor, Michigan.*

FISH PHYSIOLOGY/GYORIU SEIRIGAKU. By N. Y. Kawamoto. Ishizaki Shoten, Tokyo, 1956: 319 pp., illus. 900 yen (about $3).—Despite the presence of an English title, this book, which is well printed on good paper and solidly bound, is entirely in Japanese. The work is divided very practically into two sections, one on "Culturing Physiology" and the other on "Fishing Physiology". The former comprises chapters on circulation, respiration, physiology of the digestive system, reproduction, excretion, internal secretion, growth, and response to the physical characteristics of the water. The second section consists of chapters on the physiology of the nervous system, of the sensory systems, of the skin and coloration, osmotic regulation, migration, the swim-bladder, electrical organs, bioluminescence, and poisonous. Relatively large space is devoted to respiration and sensation. At the back of the book are a list of literature consulted (about 250 items, slightly more than half of them European and American), a subject index, an index of scientific names, and an index of common names. The work is illustrated with over 150 small figures and graphs drawn from a wide variety of sources.—WILVAN G. VAN CAMPEN, *Pacific Oceanic Fishery Investigations, Honolulu, Hawaii.*

SNAKES—MAINLY SOUTH AFRICAN. By Walter Rose. (Maskew Miller: Cape Town: 1955) xvi + 213; frontis. and 89 + 34 figs. (No price stated).—The author of this volume, VELD AND VLEI, and similar works, is well-known as a reptile and camera enthusiast. Most of the illustrations in this book are the product of his patient skill in photographing live snakes. Unfortunately, in reproduction, full justice has not been done them by the publishers. This criticism does not apply to J. H. Power's helpful series of outline drawings of the heads (crown and side views) of 34 South African species.

The scope of this chatty book, directed to the layman, is to serve as an introduction to snakes generally and South African ones in particular. Within these limits it should play a useful rôle. Taxonomists, seeking specific and detailed treatment of these reptiles, must patiently await publication of Dr. V. F. FitzSimon's long-delayed work on South African snakes. Meanwhile, Dr. Rose has had to fall back on the synoptic keys published by G. A. Boulenger in 1910 (Ann. S. African Mus.,

pp. 455–538). Where altered, the results may be utterly misleading (cf. Rose, p. 97 where keeled subcaudals have been substituted for the keeled ventrals of Boulenger, p. 507). Efforts to modernize the nomenclature has met with only partial success and fails to reflect most of the advances in South African ophiology that have been made during nearly half-a-century.

Names long relegated to the synonymy are here given a fresh lease of life. While the great majority are correctly rendered so far as binomial nomenclature will permit, others like *lalandii* ("*delalandii*"), *defilippii* ("*dephillippi*"), *haje* ("*haie*"), *mucruso* ("*mucroso*"), *nototaenia* ("*notataenia*") and *Thelotornis* ("*Theletornis*") are consistently misspelled throughout the book. *Mehelya* is sometimes spelled correctly, more often "*Mehalya*." On page 77 a cane rat appears as "*Thyonomys swinderenianus*," and the dioch weaver as "*Quealea*." Surely it is better to omit scientific names altogether rather than garble them?

As the volume is principally for South African readers, an experienced author like Dr. Rose must know what will appeal to them. Otherwise one might be tempted to question the wisdom of affording a degree of permanence to press clippings (of which the author is an avowed collector) by including so many of them in the final chapters (pp. 179–209). In view of the notorious inaccuracy, even bold mendacity, with which incidents involving snakes are reported in the daily papers, it is an open question whether any credence whatever can be placed in their unverified statements. This is, of course, a matter of personal opinion.

The slimness of the volume is deceptive owing to the size of the type (small pica) employed. Actually it contains much more letterpress than might be supposed at first glance. There is a full and adequate index.—ARTHUR LOVERIDGE, *Museum of Comparative Zoology, Cambridge, Massachusetts.*

PALÄONTOLOGIE UND PHYLOGENIE DER NIEDEREN TETRAPODEN. By Friedrich R. Freiherr von Huene. Gustav Fischer Verlag, Jena. 1956. xii + 716 pp., 690 text-figs. 88 DM (approximately $21.25 American money), bound.—This survey of the fossil amphibians and reptiles serves the valuable purpose of bringing together into one volume a comprehensive analysis and discussion of the phylogeny of the lower tetrapods. It is the culmination of 60 years of active research in the field of paleoherpetology by Professor Dr. F. R. F. von Huene of the University of Tübingen. Although Dr. von Huene is known in this country principally through his work on the dinosaurs, his competence for the present undertaking is unquestioned. Von Huene's own extensive contributions to our knowledge of the history of amphibians and reptiles, as witnessed by his numerous reports and monographs cited in the bibliographic sections of the book, appear to form the foundation for this study. His first-hand experience with material of almost all the groups covered, his fine grasp of the literature and his active contact with and intimate knowledge of the development of present ideas concerning the evolution of the lower tetrapods all give added significance to von Huene's *magnum opus*.

The work, originally written in 1945–1946 but kept up to date by additions through 1955, is organized in phylogenetic sequence from the primitive amphibian group Nectridia to the squamate reptiles. Twenty-six orders are recognized and each major group down to family and frequently to subfamily is defined on the basis of osteology. Appropriately the Aves are placed as an order of reptiles. All fossil genera considered by the author to be valid are listed or characterized. Common or especially interesting genera are illustrated by figures reproduced from many sources. The opening sections of the book deal with a discussion of basic classification, a revised system of nomenclature for the various types of vertebrae, which is essentially a modification of Gadow's 1933 (*The evolution of the vertebral column*) classification, and a consideration of the origin of the tetrapods. The next 115 pages are devoted to the groups usually placed in the Amphibia, while 561 pages contain data on the reptiles. The final portion of the book presents a discussion of the distribution in time and space of amphibians and reptiles, the major features of their evolution and the nature of the evolutionary process as interpreted by von Huene on the basis of tetrapod phylogeny. In this last section the author firmly establishes himself as a finalist who believes that a creator has caused and directed phylogeny along a planned course and toward a final goal, man. The volume is completed with a brief appendix of additions to the text, a list of standardized abbreviations utilized in the figures throughout the book and an index of generic names. An excellent bibliography is included following the treatment of each order.

It is impossible to cover adequately the contents of this bulky work within the limits of a short review. Therefore, I will limit my critical comments to sections of general importance and to the discussions of orders still represented by living examples and thus of interest to neoherpetologists.

Professor von Huene introduces his presentation to the lower tetrapods with a consideration of the origin of the group. He accepts and elucidates the now generally held concept of the evolution of terrestrial vertebrates from crossopterygian fishes. However, he will surprise and doubtless stimulate American workers, who almost universally use the Romer-Watson classification of lower tetrapods

(outlined in Romer, 1947, Bull. Mus. Comp. Zool., 99 (1), by his rejection of this system in favor of a modified version of the Säve-Söderbergh (1934, Arkiv Zool., 26A (17): 1–20) arrangement. According to the Romer-Watson theory the tetrapods are of monophyletic origin. According to Säve-Söderbergh they are a diphyletic group which originated on two different occasions from choanate fishes. Although von Huene regards the system of classification adopted and elucidated in his book as being based on a diphyletic theory of origin, he actually proposes that the lower tetrapods are a composite group composed of three main evolutionary lines each independently modified for a terrestrial existence and each independently derived from a different crossopterygian ancestor. The most ancient of these lines, von Huene's Tribus Urodelidia, contains the Nectridia, Urodela and Gymnophiona (classed as suborders of the single order Pseudocentrophi) and is presumed to have originated from the Porolepiformes group of crossopterygians. The second stock is the Ramus Batrachomorpha. This division includes the order Stegocephalia, which is equal to the order Temnospondyli of Romer's (*loc. cit.*) Labyrinthodontia, the order Anura and the order Ichthyosauria, a group usually placed with the higher reptiles. The Batrachomorpha are regarded as being derived from osteolepid-like crossopterygians. The final division, Ramus Reptiliomorpha, is regarded as an independent derivative of the Osteolepiformes and is composed of the remaining amphibians and reptiles. Romer (*loc. cit.*) has already discussed in great detail the inherent weaknesses of the Säve-Söderbergh diphyletic theory of tetrapod origins which was based upon a relatively few and minor differences in the skull and ignored completely the other characteristics shared by all primitive amphibians. Von Huene's arguments for accepting a theory so expertly discredited appear to be merely repetitions of Säve-Söderbergh's points, with the change that following Jarvik (1942, Zool. Bidrag Uppsala, 21: 235–675) the Urodelidia are now considered to be derived from the Crossopterygia instead of the Dipnoi. The essential features of von Huene's classification have previously been outlined in English (1954, Amer. Journ. Sci., 252: 181–185) and his approach has the merit of focusing attention on the critical problem of the origin of terrestrial vertebrates. It is of course clearly recognized by all workers that there is much that remains to be done to clarify the relationships of the lepospondylous Amphibia, a group probably of polyphyletic origins but almost certainly derived from aspidospondylous amphibians. However, even though our knowledge is not sufficient to completely resolve the situation, the solution offered by von Huene of considering the primitive lepospondylous forms (Tribus Urodelidia) to be a separate stock independently derived from fishes and not involved in the general evolution of tetrapods creates more problems than it solves. Only someone who attributes the entire evolutionary process to divine intervention could seriously propose that three groups miraculously similar in all essential features and all adapted in the same manner for a terrestrial existence could have been independently evolved on three separate occasions from the same ancestral stock.

The grouping of the Ichthyosauria with the Stegocephalia and Anura does not seem well-founded even though it is admitted that these aquatic reptiles have never been satisfactorily allocated (see Romer, 1948, Amer. Journ. Sci., 246: 109–121, for a more plausible solution to the ichthyosaur problem). The order Microsauria usually regarded as belonging with the Lepospondyli is placed by von Huene somewhere between the Seymouriamorpha and the Cotylosauria, again emphasizing his radical treatment of lepospondylous amphibians.

The discussion of the members of the Tribus Urodelidia is very brief, with only 10 pages devoted to fossil representatives of living groups. Four fossil families of salamanders are listed, the Lysorophidae (usually considered to be microsaurians), Cryptobranchidae, Amblystomidae and Salamandridae. No fossil caecilians are known although the group is mentioned for the sake of completeness.

The frogs and toads are classified into two suborders, the Proanura for the fossil *Amphibamus*, *Miobatrachus* and *Protobatrachus*, and the Euanura for the tailless salientians. The treatment of fossil euanurans is superficial, poorly illustrated and noteworthy only in that all of Noble's suborders are reduced to familial status and his families are regarded as subfamilies.

The sections on the groups of reptiles of interest to readers of *Copeia* are considerably more detailed than those on amphibians. Each section on orders represented by a considerable number of living species is much shorter than chapters on comparable fossil reptiles. The review of fossil turtles is among the most confusing in the text by reason of the insertion of cryptodire families before as well as after the discussion on trionychids. The confusion is further enhanced by the table of contents where the families Emydidae, Cinosternidae and Cheloniidae, among others, are placed in the suborder Trionychia. The various families of toothed fossil turtles, usually regarded as not being able to retract their necks under their shell, are considered to be members of the Pleurodira. The phylogenetic diagram of turtle evolution indicates that von Huene regards the Cryptodira as primitive and ancestral to the Pleurodira and Trionychia. The family Dermochelyidae is properly placed with the cryptodires.

Unfortunately the entire turtle section appears to have been written very early and does not seem to have been properly revised to bring it up to date. Von Huene's account ignores the recent splendid series of papers by Ernest E. Williams and although citing R. Zangerl's work up to 1953, makes little use of it in the text. The entire section is marred by listings of invalid generic names and emendations such as *Nicoria*, *Bellia*, *Cachuga*, *Cistudo* and *Trachemys* among the Emydidae and *Devisia* and *Cinosternum* among the chelydrids.

The discussion of the crocodilians is one of the most interesting in the book. Von Huene has done considerable work with fossil members of the order and his report presents a rather full but radical analysis. His conclusions expressed in a dendrogram are particularly revealing when compared to those recently published by Kälin in the *Traité de Paleontologie* (see below). Von Huene is in sharp disagreement with Kälin at almost every point, from the families to be placed in his three suborders, Protosuchia, Mesosuchia and Eusuchia (Kälin recognizes an additional suborder the Sebecosuchia, allocated by von Huene to the Eusuchia), to the interrelationships within each group. It is significant that no mention is made of Kälin's important papers on crocodiles in the present work.

The Rhynchocephalia are one of von Huene's specialties and he gives an enlightening account of the fossil ancestors of the living tuatara. In this discussion the primitive position of *Sphenodon* within the order is re-affirmed and its relationship to the fascinating and bizarrely beaked advanced forms are elucidated. The evidences for the close association between the order and the Eosuchia are detailed.

Von Huene divides the Squamata into three suborders, Prolacertilla, Lacertilla and Ophidia. He rejects the protosaurian theory of origin for the group and presents evidence to support the eosuchian ancestry of the order. He places *Prolacerta* and its allies as squamates, thus removing them from their sometime association with the eosuchians. Also included as prolacertillians are several genera including *Paliguana*, *Thalattosaurus* and *Clarazia* frequently grouped as eosuchians or rhynchocephalians. The so-called Triassic squamates *Akeptosaurus*, *Macrocnemus* and *Tanystropheus* are also placed here. The classification of the remaining fossil lizards follows Camp's (1923, Bull. Amer. Mus. Nat. Hist., 48; 11) now somewhat outmoded but classic arrangement. The snakes are summarily treated with the interesting innovation of including all living species within the limits of the single family Alethinophidae.

The book is adequately bound and the paper and format are of good quality. Although the printer, Gustav Fischer, is one of the famous names among scientific publishers it is obvious that the firm is not up to its pre-World War II standards. Typographical errors are frequent as for example Cressopterygia on page 3 and the upside down figure on page 661, among others. The general excellence of the book's appearance is detracted from by the uneven quality of illustration. Many figures are very good but many are so poor as to be of little use and one questions the need for their reproduction (figures 11, 153, 223, 224, 247, 276, 331, 473 and 597 are examples). The liberal use of phylogenetic diagrams is an attractive feature. One of the most inconsistent things about the book is the use of zoological nomenclature. Von Huene apparently knows nothing about the International Rules or if aware of them ignores their existence. He utilizes such terms as Tribus and Grade for suprafamilial groupings, the former for about the equivalent of subclass, the latter for suborder. In addition terms such as Amphicoelia and Dislasiocoela are employed as family names and Pipidae and Bufonidae as subfamily names. Family names without type genera, as for example Riptoglossidae in the table of contents and Alethinophidae are given. Many invalid and unavailable generic names are listed in every group.

It is only natural to make comparisons between the present work and the recently published (1955) *Traité de Paleontologie* volume edited by Piveteau and reviewed in this journal by Williams (1956: 130–132). Both books cover essentially the same ground but in a very different manner. The *Traité* is the work of a group of 14 contributors with varying degrees of familiarity with the studied organisms. Von Huene has done the entire job himself and although the task is unevenly accomplished his book has a certain continuity of purpose not recognizable in the French review. The two books are strikingly similar in many features. Both are equally valuable as atlases, both are exceedingly expensive, both suffer from remarkable inequalities of coverage of different groups, both slight the fossil representatives of living orders, both must be used with extreme caution and both are outstanding in their treatment of particular groups on which the respective authors are essentially the world's authorities. Von Huene's contribution is not as sumptuously provided with glossy paper, uniformity of redrawn figures and beautiful binding, but it does not suffer by comparison with the *Traité* volume because the author has had so much personal experience with the animals covered. As a final point of comparison the number of pages devoted to each order represented by still surviving members can be listed for von Huene's account first and those in the Piveteau volume in parentheses:

Caudata 7 (8), Gymnophiona 1 (0), Anura 7 (36), Testudinata 34 (58), Rhynchocephalia 18 (21), Squamata 37 (86) and Crocodilia 38 (91).

Actually von Huene's book is more reminiscent of another recent major work (W. K. Gregory, 1951, *Evolution Emerging*) than it is of the *Traité*. Although Gregory treats a wider field than von Huene both of these books agree in being a compendium of information on the vast subject of vertebrate evolution. Both are based in large part on previous researches by their authors, frequently reproduced as originally presented and unmodified by the studies of subsequent workers. Both are extremely useful as atlases and as a central source of reference to the ideas of their authors, which previously were scattered through the literature. Both suffer from a fundamental archaic appearance induced by the retention of theories long disproved and in the disregard of many recent findings of great significance. Furthermore the two works stand as the mature attempts of two experienced workers at an evolutionary synthesis.

The final evaluation of von Huene's book is that it is a mixture of sound and unsound features. It is useful as a summary of a diffuse array of fossil organisms, as a comprehensive report on a lifetime of work by an important paleontologist specializing in amphibians and reptiles and as an excellent guide to the literature. Balanced against these must be the acceptance of a radical and unproven theory of tetrapod origins, controversial classifications of many groups and the uneven treatment provided by the author. Few neoherpetologists will find that this work is essential to their research and hardly any can afford the extreme cost. However, von Huene's book still forms an important item which should be available for reference in most institutional libraries.—JAY M. SAVAGE, *Department of Biology, University of Southern California, Los Angeles 7, California.*

EDITORIAL NOTES AND NEWS

ASIH New Orleans Meeting

The local board for the 37th annual meeting is anticipating a record attendance. Advance programs will be distributed March 30 to all members who indicate their interest in attending by sending a postcard to FRED R. CAGLE, Department of Zoology, Tulane University. The advance announcements will provide details of the program, field trips, and motel information.

Special arrangements have been made with Mr. George Douglass, Superintendent of Audubon Park, for persons to camp. Toilet facilities and wash basins will be available. Audubon Park is directly opposite the Tulane campus and within 20 minutes (by street car) of the Jung Hotel where the meetings will be held. Members desiring to camp are urged to make advance arrangements by writing to FRED R. CAGLE.

Grants-in-Aid Oklahoma

The University of Oklahoma announces that a grant from the National Science Foundation has provided funds for a number of grants-in-aid to be awarded to competent students and investigators in biology for the 1957 summer session at the University of Oklahoma Biological Station, Lake Texoma. Three types of grants are available: (1) postdoctoral grants of $500; (2) predoctoral grants of $350; (3) $200 grants to superior undergraduates or beginning graduates. The investigations pursued must be suitable for the Biological Station.

Applications for grants-in-aid should be made by April 10, and should be sent to: DR. CARL D. RIGGS, Director, University of Oklahoma Biological Station, Norman, Oklahoma.

Copeia Mailing Dates, 1956

Copies of Copeia for 1956, mailed first-class to the Editor-in-Chief, were postmarked at Baltimore, Maryland as follows: No. 1, March 3; No. 2, June 5; No. 3, Sept. 10; No. 4, Jan. 8 (1957).

Publication Costs

Many organizations providing funds for research approve the payment of publication costs. Any member applying for a research grant should insure that his application includes a budget item for this purpose. The provision of such aid in publication will contribute toward increasing the amount of material published in Copeia.

ASIH Western Division The 25th annual meeting was held in Seattle, Washington June 14, 1956. The following officers were elected: President, FRANCES N. CLARK; Vice-President, ANGUS M. WOODBURY; Secretary-Treasurer, LILLIAN J. DEMPSTER. Prizes for the best two student papers were awarded to Mr. ERNEST L. KARLSTROM, Herpetology and Mr. M. A. ALI, Ichthyology.

Dunn Memorial Number COPEIA number 2 will be a memorial to DR. E. R. DUNN. Members desiring to make a special contribution of financial support toward the publication of this number may send their checks to the Editor-in-Chief.

National Science Foundation The National Science Foundation has announced the award of the following grants of interest to members of the Society: KENNETH R. JOHN, University of Wyoming, "Predator-Prey Relationships in a Fish Community", $6,500; EDGAR ANDERSON, Missouri Botannical Garden, "Phylogeny and its Application to Systematics (Conference)", $1,500; S. CHARLES KENDEIGH, University of Illinois, "Physiological and Ecological Studies of Manitoba Flora and Fauna", $6,900; Science Service, "Fellowships for Science Teachers in Universities and Colleges", $3,200; Federation of American Societies for Experimental Biology, "National Register of Scientific and Technical Personnel in the Field of Biology", $12,500; Georgetown University, "Research in Mechanical Translation", $100,000; Library of Congress, "Reference Center for Reports on Government - Supported Scientific Research", $17,500; National Academy of Sciences, "The Need for Preserving Primary Scientific Records", $10,000; American Institute of Biological Sciences, "General Conference of Editors of Biological Journals", $16,675; American Institute of Biological Sciences, "Maintaining the National Register of Scientific and Technical Personnel in the Field of Biology", $20,650; JOHN W. MARR, University of Colorado, "Ecology of Certain Areas in the Alaska Range", $8,800.

Few ichthyologists or herpetologists have made their research needs known by requesting help from the National Science Foundation. The address: 1520 H Street, NW, Washington 25, D. C.

U. S. National Museum The division of fishes, U. S. National Museum was 100 years old on December 15, 1956. It was on that date that the first entry was made in the catalogue. Since then a total of 157,424 additional entries have been made.

In celebration of this centennial it was announced that a new position of associate curator of fishes was filled by the appointment of Dr. WILLIAM RALPH TAYLOR on December 3, 1956.

Michigan Institute for Fisheries Research Recent additions to the staff include the following: Dr. PAUL H. ESCHMEYER became Assistant Director on May 1, 1956; he was formerly employed as biologist in charge of lake trout investigations in the Great Lakes for the United States Fish and Wildlife Service. Dr. THOMAS F. WATERS started on June 18 as Fisheries Biologist in charge of the Pigeon River Trout Research Station at Vanderbilt; he had just completed his doctoral degree with Professor R. C. BALL at Michigan State University, with the help of a National Science Foundation fellowship, on problems of lake fertilization. Mr. MERCER H. PATRIARCHE joined the staff on June 11 as Fisheries biologist in charge of the Rifle River Fisheries Research Station at Rose City; he was formerly employed by the Missouri Conservation Commission as Fisheries Biologist in charge of investigations on impounded waters in that state. Dr. JOHN E. WILLIAMS is in charge of the newly established warm-water Fisheries Research Station at Hastings.

Cornell In the nearly four years since news of Cornell fish work last appeared in COPEIA, the Ph.D. degree has been completed by the following: RONALD WARD CRAWFORD, 1953; dissertation, "A study of the distribution and taxonomy of the percid fish *Hadropterus nigrofasciatus* Agassiz"; now a member of the faculty of San Diego State College, San Diego, California. EARL EDWARD DEUBLER, JR., 1955, "A taxonomic study of the cyprinid fish, *Clinostomus vandoisulus* (Valenciennes), in eastern United States"; now on the faculty of the North Carolina University's Institute of Fisheries Research, Morehead City, North Carolina. ROBERT HENRY GIBBS, JR., 1955, "A systematic study of the cyprinid fishes belonging to the subgenus *Cyprinella* of the genus *Notropis*"; now Research Associate, Woods Hole Oceanographic Institute. HELEN JOSEPHINE ILLICK, 1953, "A comparative study of the lateral line system on the head of North American Cyprinidae"; now on faculty of Russell Sage College, Troy, New York. LORA MILTON OUTTEN, 1956, "Studies of the life histories of the cyprinid fishes *Notropis coccogenis*, *Notropis galacturus* and *Notropis rubricroceus*"; now on the faculty of Mars Hill College, Mars Hill, North Carolina. CHARLES RICHARD ROBINS, 1954, "A taxonomic revision of *Cottus bairdi* and *Cottus carolinae* species group in eastern North America (Pisces, Cottidae)"; now on

the faculty of the Marine Laboratory, University of Miami, Coral Gables, Florida. WILLIAM STARNOLD WOOLCOTT, JR., 1955, "Comparative osteology of the serranid fishes of the genus *Morone* (Mitchill) and infraspecific variations in *Morone americanus* (Gmelin)"; now on the faculty of the University of Richmond, Virginia.

JERRAM LEFEVRE BROWN who finished the Master's degree in February 1954 is continuing his graduate studies at the University of California at Berkeley. His thesis was "A review of the cyprinodont genus *Fundulus* of eastern United States." ROBERT MINTURN LEWIS completed the Master's degree in 1956, using for his thesis "A comparative study of populations of the striped bass, *Roccus saxatilis* (Walbaum), based on gill raker counts"; now on the staff of the Fishery Laboratory of the U. S. Fish and Wildlife Service, Beaufort, North Carolina. After finishing his Master's degree in September 1956, WILLIAM ALBERT LUND, JR. has begun a study of the biology of the bluefish, *Pomatomus saltatrix*. His master's thesis was "A morphometric study of the striped bass, *Roccus saxatilis* (Walbaum)." Mr. LUND's studies on bluefish and continuing studies on the striped bass by WALTER S. MURAWSKI are supported by awards from the Sport Fishing Institute.

EDWARD C. RANEY continued his studies of the systematics and distribution of the freshwater and euryhaline fishes of eastern United States with the aid of a National Science Foundation grant which will support the project for three years. HELEN J. ILLICK has also received assistance from the National Science Foundation to continue her studies on the cephalic canals of cyprinid fishes.

News Notes

The United States Fish and Wildlife Service has announced the retirement of Mr. ISAAC GINSBURG, who has served for 35 years as ichthyologist with the Service's laboratory in the Division of Fishes, U. S. National Museum. Mr. GINSBURG will continue his studies of the fishes of the Gulf of Mexico in the National Museum laboratory on a temporary basis after the date of his formal retirement. The Fish and Wildlife Service has also announced the assignment of Dr. GILES W. MEAD to their National Museum laboratory. Dr. MEAD, who has recently completed a tour of military service with the Chemical Corps, U. S. Army, was formerly with the North Atlantic Fishery Investigations, Woods Hole, Massachusetts.

Dr. MAURICE BLACKBURN, formerly principal research officer for the Australian federal fishery program, has filled the position of Professor in the Department of Zoology and Entomology at the University of Hawaii vacated by Dr. A. L. TESTER and held last year by Dr. F. E. J. FRY, on temporary leave of absence from the University of Toronto.

During August and September, 1956, JORGE CARRANZA, of the Mexican Dirrección General de Pesca e Industrias Conexas, was in Mazatlán establishing, for the fisheries department, the Estacion de Biologia Marina de Mazatlán (Casa del Marino, Mazatlán, Sinaloa). Several lines of research are being undertaken and personnel is being trained. For the previous two years, Señor CARRANZA conducted a survey of the aquatic resources of the Península de Yucatán. It is intended to expand certain phases of that project for a doctoral thesis at the University of Michigan.

A Section of Animal Behavior and Sociobiology of the Ecological Society of America has been organized. The purpose of the Section is to advance, coordinate, and assist research and publications on the subject of animal behavior and social organization basic to theoretical science and human welfare, and to act as a liaison agency between workers in the various scientific fields concerned. The officers are: Chairman, Dr. J. P. SCOTT, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine; Vice-Chairman, Dr. A. M. GUHL, Kansas State College, Manhattan, Kansas; Secretary, Dr. M. W. SCHEIN, Pennsylvania State University, University Park, Pennsylvania.

A new list of sales publications of the New York State Museum is available on request to the Museum at Albany 1, New York. The revised list includes a considerable number of zoological bulletins, circulars, handbooks, etc., that were formerly considered out of print and have been available only through dealers.

The University of Louisville has announced the creation of an endowed professorship of conservation, made possible by a gift of $235,000 from anonymous donors. This chair in the Biology Department will be named in honor of TOM WALLACE, editor emeritus of *The Louisville Times* and a national figure in the conservation movement of this country.

Dr. FRED R. CAGLE has been appointed Director of a National Conference of Biological Science Editors. The conference is sponsored by the American Institute of Biological Sciences and financed by the National Science Foundation.

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